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PRE-IMPOUNDMENT STUDIES OF THE WATERS OF THE CROSS-FLORIDA BARGE CANAL (OKLAWAHA AND WITHLACOOCHEE R)

Federal Water Pollution Control Administration
Athens, Georgia

December 1967

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CROSS FLORIDA BARGE CANAL

PRE-IMPOUNDMENT STUDIES

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST WATER LABORATORY

December 1967

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CROSS FLORIDA BARGE CANAL
PRE-IMPOUNDMENT STUDIES

I) INTRODUCTION

On June 2, 1966 and in subsequent correspondence, the Jacksonville District office of the U. S. Army Corps of Engineers requested the Federal Water Pollution Control Administration to undertake extensive studies of surface water quality prior to, during and after construction of the Cross Florida Barge Canal. This responsibility was accepted by the Federal Water Pollution Control Administration and proposals were submitted to the Corps of Engineers on January 12, 1967 and February 9, 1967. These proposals called for a three phase study: a preimpoundment survey to determine water quality before any significant disturbance of the environment; an intermediate phase emphasizing automated instrumentation and seasonal sampling to ascertain the degree of water quality response as each of the major projects are completed; a postimpoundment survey after completion and operation of the system for a time sufficient to attain a steady state condition with regard to water quality. The Corps of Engineers accepted these proposals on March 15, 1967. A general study plan listing objectives and tentative scheduling was submitted on April 11, 1967. A detailed study plan for the preimpoundment survey was also submitted at this time. The preimpoundment phase of this study extended from April to September 1967. This report is a summation and interpretation of the data gathered during this phase.

Cooperation in the form of additional data, reports and other information necessary to the preparation of this report was received from the Corps of Engineers, U. S. Geological Survey, Bureau of Sport Fisheries and Wildlife, Florida Fresh Water Game and Fish Commission and the Southwest Florida Water Management District. Their contributions to this report are gratefully acknowledged.

II) SUMMARY AND RECOMMENDATIONS

Physical, chemical and bacteriological water quality studies of the proposed Cross Florida Barge Canal area were conducted in March and April of 1967 to determine conditions before significant construction activity on the major impoundments in the canal took place. In general, water quality in the proposed impounded areas was excellent and should be acceptable if maintained at these levels for the proposed contact and non-contact recreational uses. The report discusses the problems which may effect water quality.

However, there are problems which are presently localized but which, if not carefully controlled, may impair the desired uses. The operation of the Moss Bluff Dam for flood control purposes and the storage of water in Eureka Dam may cause backwater in the Eureka impoundment to extend far up the Silver River toward Silver Springs. It is imperative that the Corps of Engineers strictly control the release of water from Moss Bluff Dam so that there is no possibility of drowning Silver Springs with Oklawaha River water during the flood season. This will require an effective coordination with releases from the proposed Eureka and Rodman Dams.

Low dissolved oxygen from Silver Springs as well as reduced oxygen levels in the Oklawaha River above Silver Springs due to oxidation of organic material discharged from Moss Bluff Dam may cause dissolved oxygen to be below acceptable levels for recreational use in the headwaters of the Eureka impoundment. This condition would tend to be more severe in the summer months when higher temperatures will accelerate the rate of oxygen utilization in the Oklawaha River and also reduce the saturation value of dissolved oxygen in water. In addition, when the impoundment is constructed, the greater depth and sharply reduced velocity will severely limit reaeration.

Total coliform densities in the Oklawaha River are not representative indicators of discrete waste inputs. Using fecal coliform as a yardstick, the Oklawaha River in the proposed Rodman pool area in and around Orange and Cabbage Creeks showed increased densities probably resulting from the town of Interlachen and the fishing camps near this location. These camps will probably be eliminated by construction of the canal but they do serve as an indication of the effect which proposed recreational development of this area may have on bacterial quality levels acceptable for these uses.

The Withlacoochee River had excellent chemical quality at all locations. The area in and around Dunnellon, Florida, showed higher total coliform densities but the average concentrations in all cases were acceptable for recreational usage.

The recommendations of this report are:

1) Automatic monitoring equipment should be installed for dissolved oxygen temperature conductivity and pH at the

State Route 40 bridge in the Eureka pool below the confluence of the Silver River and the Oklawaha River to be sure that oxygen levels in the headwaters are acceptable. Analyses for color and/or conductivity should be made downstream of Silver Springs on the Silver River after the filling of the Eureka pool to monitor the extent of the backwater into the Silver River and to prevent the possibility of contamination of Silver Springs with Oklawaha River water. Monitors for chlorides and/or conductivity should be installed on the impoundment ends of the St. Johns and Inglis locks in order to assess the significance of salinity intrusion from the operation of these locks.

The Corps of Engineers has indicated to FWPCA its intention to install automatic monitoring devices at each of the proposed dams upon completion of construction and commencement of releases. However, water quality at these locations is not expected to present a problem. Therefore, it may be possible in the immediate future to make judicious use of available personnel at each dam until the need for automatic equipment is demonstrated. This is also applicable at Moss Bluff Dam.

2) All waste sources, existing and potential, should provide the maximum degree of treatment feasible including disinfection. Effluent from recreational facilities should be

discharged below the recreation area and, when located near proposed dams, should be discharged into the tailrace below the dam.

3) Dredging spoil wherever possible should be disposed of on upland areas. When this is not possible, the spoil area should be diked and weired by dragline and disposal should be to the upland side of the fill area.

4) Any programs initiated to control hyacinths in the impoundments should employ manual methods and the resultant organic material should be harvested and removed from the system.

III) AREA

The Cross Florida Barge Canal will extend for 109.8 miles from just south of Palakta, Florida, on the St. Johns River near the Atlantic coast to the Gulf of Mexico, south of Yankeetown, Florida. The channel will be 150 feet wide and 12 feet deep and will follow existing river beds of the Oklawaha and Withlacoochee Rivers. A new thirty-mile channel will be cut across central Florida from Silver Springs on the Oklawaha River to Dunnellon on the Withlacoochee River. Five locks will be constructed near the St. Johns River, Eureka, Silver Springs, Dunnellon and Inglis that will raise the canal from sea level to a maximum pool elevation of 55 feet above mean sea level between Silver Springs and Dunnellon. There will be three major impoundments creating 30,000 acres of surface waters which will be extensively developed for swimming, boating and fishing. These will be the Rodman pool from about five miles east of Orange Springs to Eureka; the Eureka pool extending from Eureka Dam to south of Silver Springs; and the already existing Inglis pool on the Withlacoochee River. This pool has been used for power purposes by the Florida Power Company.

It is with these impounded areas and their proposed recreational development that this report is primarily concerned. The major justification for the construction of the canal is the benefit accruing to navigation. However, water quality suitable for navigation is minimal and would not represent a problem in any case. It is with water quality necessary to sustain the anciliary benefits of contact and non-contact recreation that problems may arise associated with construction and development of the canal.

The following information is contained in other published reports concerned with evaluation and feasibility of the Cross Florida Barge Canal but is presented here to provide continuity and cohesion to the interpretation of surface water quality data.

Construction of the canal originally was programmed to be completed in 1972. At the present time, completion of the project is not expected before mid 1974. The cost of the entire project was estimated in 1964 at approximately $157,000,000. Rodman pool will be filled by April 1968 with dredging of the channel completed by July 1970; Eureka pool by May 1970 with dredging completed by November 1972; and dredging of the channel from Dunnellon to Inglis lock in the Inglis pool should be completed by March 1971. It is presumed that recreational land development will be completed at the same times.

The Corps of Engineers as coordinator for recreational development intends to establish 25 major use areas along the canal together with several other non-designated areas. Visitations at these areas are projected at 2,300,000 in 1970 increasing to 3,700,000 when the entire project is completed in 1974. The average annual benefit for primary outdoor recreation assigned over the life of the project (1970 to 2020) is $3,142,000. Proportioning this benefit on projected attendance figures indicates that 54% of the benefits will be realized in the three impounded areas. Another 20% will accrue to the development of Silver Springs lock with the remaining 26% distributed in other project areas. The activities of boating, camping and swimming will provide 84% of all benefits. Fishing, however, will only produce about 1.2% of the total benefits. When it is considered that the average annual benefit from freight transportation barging, the major use of the waterway, is estimated at $6,980,000 per year, recreation becomes a highly significant factor in the economy of the project. The estimated annual costs of recreational development are $680,000 including management and maintenance giving a benefit cost ratio of 4.6.

The major agricultural development in the area is citrus growing around Inglis Lake. Muck farming is conducted in the area of the Oklawaha River between Moss Bluff and Sharpes Ferry. With regard to industrial development and the possibility of significant point sources of pollution, the Corps of Engineers has stated that only smaller industries would be permitted, and then only if they did not deleteriously interfere with the purposes of the project including recreation, preservation of health, conservation, enhancement of fish and wildlife and the prevention of pollution. It is not expected that industrial development will become a significant factor in considering levels of water quality, but each individual proposal should be evaluated by appropriate State and Federal water pollution control agencies. All recreational facilities will be required to install treatment devices that will not interfere with the designated uses. This provision will also apply to any boats permanently moored in the area.

In view of the above discussion, interpretation of water quality data will be evaluated for suitability for recreational purposes, particularly boating and swimming.

IV) WATER QUALITY

The preimpoundment survey to determine water quality levels prior to major project construction in the impoundment areas was conducted by FWPCA personnel during March and April 1967. These studies consisted of hydrological, chemical, bacteriological and biological analyses of samples collected at twenty-one stations in the Oklawaha and Withlacoochee basins. Analysis of samples was conducted according to procedures listed in the twelfth edition of Standard Methods for the Examination of Water and Wastewater. The sampling stations were chosen to complement the extensive ground water network developed by the U. S. Geological Survey. A description of the sampling stations is contained in Table I and the study area is shown in Figure I. A summary of data follows the discussion. A special biological survey was conducted by staff of the Technical Advisory and Investigations Branch, FWPCA, Cincinnati, Ohio. This report is appended.

A. Hydrology:

1) Oklawaha River

The Oklawaha River originates from the drainage of a series of lakes located generally between Orlando and Ocala, Florida. Drainage is regulated at Moss Bluff by a Corps of Engineers lock and dam. The water quality studies discussed in this report were conducted below Moss Bluff Dam. Immediately prior to the field survey, the Corps began construction to

TABLE I

DESCRIPTION OF SAMPLING STATIONS

A. Oklawaha River

01 - Oklawaha River from State Route 19 Bridge

02 - Oklawaha River near U.S.G.S. stream gage at Riverside landing. Bank sample.

CC3 - Cabbage Creek from State Route 310 Bridge

04 - Oklawaha River at Cedar Landing - dirt road one-half mile south of SR 310-315 junction. Sample is to be taken from boat launched at Orange Creek ferry.

OC5 - Orange Creek from Route 21 bridge in Orange Springs

06 - Oklawaha River 100 yards above Orange Creek ferry. Sample taken from boat launched at Orange Creek ferry.

07 - Oklawaha River from SR 316 Bridge behind Eureka Lock and Dam construction area.

08 - Oklawaha River from SR 40 Bridge E. of Silver Springs

S.S.9- Silver Spring's surface water sample in Silver Springs Park off SR 40. Bank sample.

010 - Oklawaha River at Sharpes Ferry Bridge S.E. of Silver Springs near future Silver Springs Lock.

011 - Oklawaha River from SR 464 Bridge just below Corps of Engineers Moss Bluff Lock and Dam

B. Withlacoochee River

W1 - Withlacoochee River from Highway 19 - 98 Bridge

W2 - Withlacoochee River immediately downstream of tailrace of Inglis Dam at public boat ramp

I3 Top & I3 Bottom - Inglis Lake from Inglis Dam

I4 Top & I4 Bottom - Inglis Lake about 7.5 miles below Dunnellon - approximately two miles north of SR-488 on road to River Oaks Trailer Park and Fishing Camp. Sample will be taken in mid-channel of Lake from a boat launched at fishing camp.

I5 - Inglis Lake about one mile below Dunnellon. Sampling station is at the end of the first road to the right just west of U.S. Highway 41 on SR-488. Bank sample

W6 - Withlacoochee River from U.S. 41 Bridge south of Dunnellon

BR7 - Blue Run River 2.1 miles north of Highway 40 and 41 intersection in Dunnellon. Turn east on paved road - cross ACL tracks and continue north to public boat ramp and picnic area. Bank sample off dock.

W8 - Withlacoochee River from SR-200 Bridge remodel this 40 year old installation and considerably reduced the discharge through the dam. During the period of study, flow in the Oklawaha River below Moss Bluff averaged 70 cfs compared to a normally expected discharge of about 400 cfs. Therefore, the mass contribution of chemical and physical constituents was not accurately represented during this period. However, there is no reason to believe that the concentrations observed are non-representative. These concentrations permit extrapolation of the results to more normal river discharges.

The Silver River, which carries the inflow from Silver Springs near Ocala to the Oklawaha River, averaged 920 cfs during the period of study. This is about the normally expected flow. The river flows through Ocala National Forest in the area which will be impounded by Eureka Dam. Present plans show that water in the Oklawaha River will be impounded to a point approximately nine miles above the present confluence with the Silver River. Some of the Silver River near the mouth will be impounded, but the backwater will not reach Silver Springs. However, the Corps shows a maximum pool elevation in the Eureka impoundment of 40 feet above mean sea level. According to the U. S. Geological Survey Water Supply Papers and Quadrangle Maps, Silver Springs is at an elevation of less than 40 feet (38.96 ft.).

It is imperative that the Corps of Engineers strictly control the release of water from Moss Bluff Dam so that there is no possibility of drowning Silver Springs with Oklawaha River water during the flood season. This will require an effective coordination with releases from the proposed Eureka and Rodman Dams.

Orange Creek,which enters the Oklawaha River near Orange Springs,drains an area of 431 square miles, and during this study had an average discharge of 180 cfs. The Oklawaha River at Riverside Landing just above the construction site of Rodman Dam averaged 1,630 cfs. Flow at this point was about 20% less than would have been observed if the Moss Bluff Dam had been operated normally.

2) Withlacoochee River

The Withlacoochee River rises in a lake district northeast of Tampa, Florida, and flows north to near Dunnellon where it turns west and discharges to the Gulf of Mexico. That part of the drainage area below Lake Tsala Apopka will be affected by construction of the Cross Florida Barge Canal. During the period of survey, the Withlacoochee River immediately below Lake Tsala Apopka near Holder, Florida, had an average flow of 630 cfs. Blue Run, the major tributary in this reach, originates at Rainbow Springs and discharges 790 cfs to the Withlacoochee River at Dunnellon, Florida. Inglis Dam, a

16. A

hydroelectric facility, impounds the river to form Lake Inglis that extends upstream to Dunnellon. Flow through the gate at Inglis Dam averaged 1,170 cfs. During the study the inflow to the lake was greater than the outflow by about 250 cfs.

Construction on the Canal will entail a dredged channel through Inglis Lake; reconstruction of the dam and a lock to provide passage northwest of the dam.

A summary of the observed flows in the Oklawaha and Withlacoochee Rivers and a comparison with normally expected discharges is contained in Table II.

B. Chemical and Physical Parameters:

1) Oklawaha River

Chemical and physical parameters of water quality in the Oklawaha River were generally excellent during the pre-impoundment survey. Figures II and III illustrate profiles of several significant criteria. At the sampling station below Moss Bluff Dam, (O-11) dissolved oxygen averaged 7.7 ppm which is 83% of saturation at the observed water temperature of 19.5°C. The five-day biochemical oxygen demand (BOD), a measure of available organic material, was higher than would normally be expected for an unpolluted stream. Values averaged 3.9 ppm with a maximum of 5.6 ppm. These values reflect the organic

17-A

TABLE II

SURFACE WATER DISCHARGE*
CROSS FLORIDA BARGE CANAL STUDY AREA
March-April 1967

LOCATION	OBSERVED DISCHARGE cfs	EXPECTED DISCHARGE* cfs
A) Oklawaha River		
Moss Bluff Dam	70	404**
Sharpes Ferry	90	487
Silver River at Silver Springs	920	785
Orange Creek at Orange Springs	180	218
Riverside Landing	1630	2300
B) Withlacoochee River		
Holder	630	1130
Blue Run	790	-
Inglis Dam	1170	-

* From monthly observations in U.S.G.S. Water Supply Papers

** 12 years of record only (1943-55)

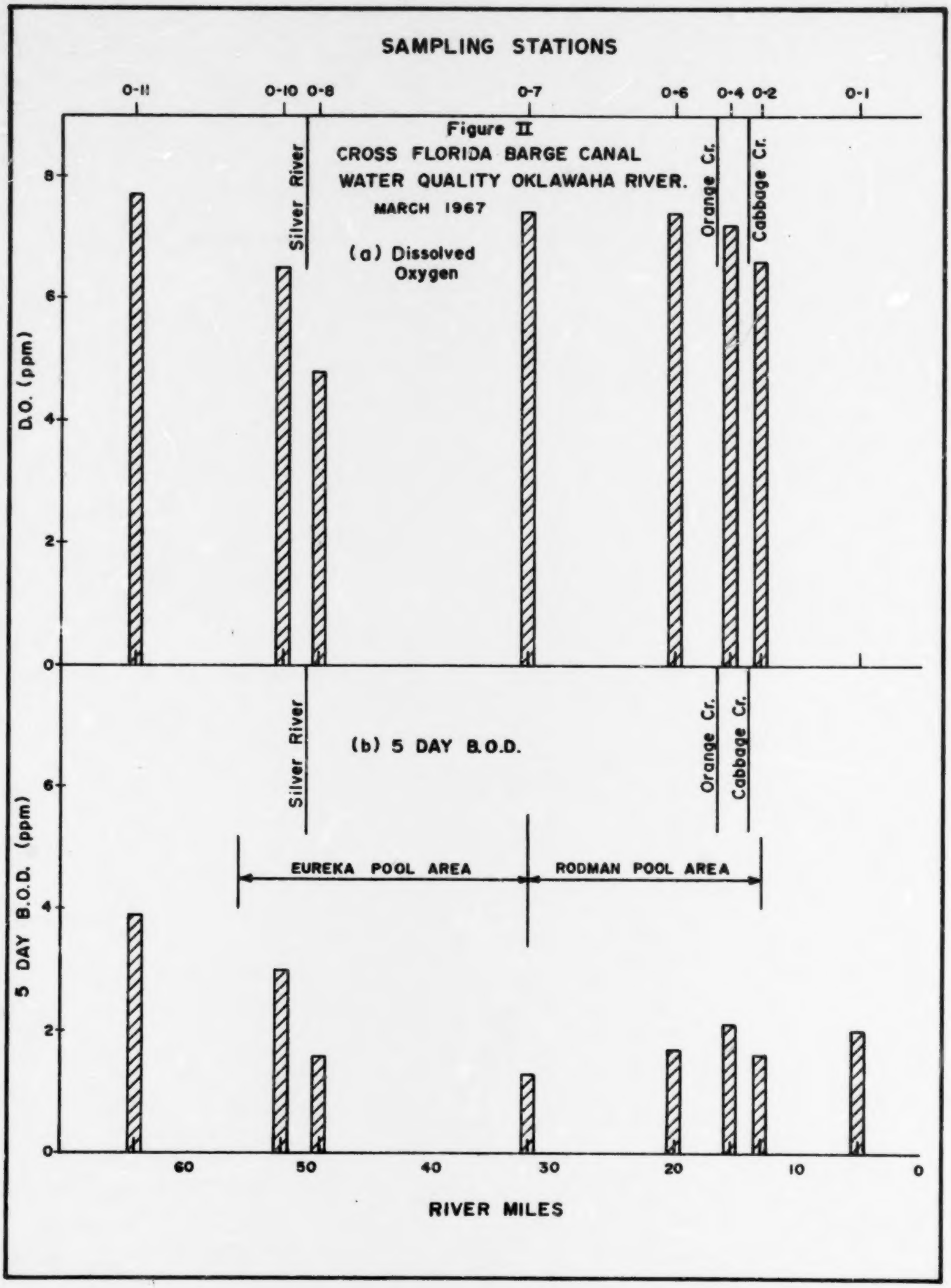


Figure II
CROSS FLORIDA BARGE CANAL
WATER QUALITY OKLAWAHA RIVER.
MARCH 1967

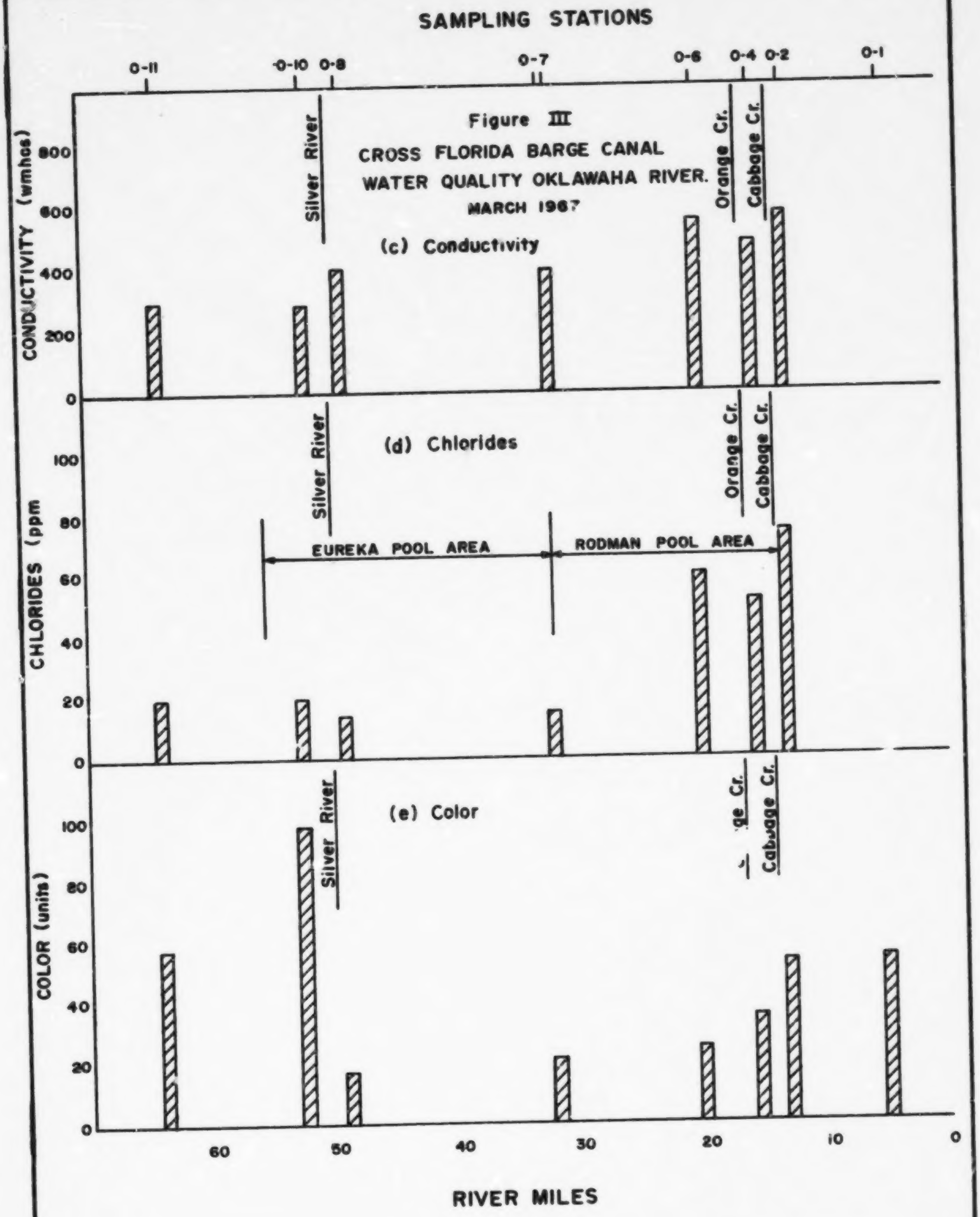


Figure III
CROSS FLORIDA BARGE CANAL
WATER QUALITY OKLAWAHA RIVER.
MARCH 1967

material produced in the lake above Moss Bluff by biological activity. This is shown by the high concentration of organic nitrogen observed at this point (4.6 ppm). The water has a relatively high color concentration averaging 57 units. This is attributable to lignins and tannins derived from the low drainage area lands in the upstream watershed.

At Sharpes Ferry upstream of Silver Springs, which will be in the headwaters of the Eureka impoundment, (0-10), dissolved oxygen had been reduced to 6.5 ppm primarily by satisfaction of available organics discharged through Moss Bluff Dam. This is shown by the reduction in 5-day BOD to an average of 3.0 ppm. The muck farms in the stretch between Moss Bluff and Sharpes Ferry have little noticeable effect on water quality as shown by the fact that total solids remained constant at 224 ppm versus 222 ppm at Moss Bluff. Color, however, increased to 98 units because of land drainage.

At Silver Springs itself, (SS-9), water quality reflects the underground artesian source. Color is, for all purposes, absent with a reading of 5 units being recorded. Total solids and conductivity are higher than in the Oklawaha River. Alkalinity and hardness are about twice as great in water from Silver Springs. The most significant factor in terms of the new impoundment is the relatively low D.O. observed compared to other points. Dissolved oxygen at Silver Springs averaged 3.9 ppm mainly due to lack of exposure to the atmosphere and the pressurized condition of the artesian aquifer. Flow from Silver Springs normally makes up about half the total discharge of the Oklawaha River below the confluence. Therefore, the depressed D.O. observed at Sharpes Ferry on the Oklawaha River when combined with the relatively low D.O. from Silver Springs may cause inadequate dissolved oxygen to occur in the headwaters of the Eureka impoundment. This possibility is demonstrated by the average D.O. of 4.8 ppm observed in the Oklawaha River below the confluence (0-8). This condition would tend to be more severe in the summer months when higher temperatures will accelerate the rate of oxygen utilization in the Oklawaha River and also reduce the saturation value of dissolved oxygen in water. In addition, when the impoundment is constructed, the greater depth and sharply reduced velocity will severely limit the ability to absorb oxygen from the atmosphere through reaeration.

A sampling station was located just above the proposed site of Eureka Dam (0-7). A large recreation area is projected for this location. Dissolved oxygen averaging 7.4 ppm and 5-day B.O.D. at 1.29 ppm is indicative of a relatively unpolluted condition. There is a sharp increase in chlorides through the proposed pool area from 15 ppm to 60 ppm. This is due to drainage from Mud Lake, Lake Eaton and Lake Charles. This level of chlorides is still well below concentrations of concern for fresh water fish and aquatic life. Based on the data collected during this survey, the physical and chemical parameters in the Eureka pool should be acceptable for recreational purposes when construction is completed. This conclusion is predicated on the maintenance of an adequate D.O. at the headwaters and effective waste treatment at the recreation installations. It is recommended that treated wastes be introduced downstream of the recreational development and, when located near proposed dams, should be discharged into the tailrace below the dam.

The Oklawaha River in the area of the proposed Rodman pool (0-6, 0-4, 0-2) had excellent chemical and physical water quality. The minimum D.O. observed was 6.0 ppm. Drainage from the swampy areas north of Silver Springs caused color to gradually increase to about the value observed at the outlet of Moss Bluff Dam. The major tributaries to the Rodman pool area, Orange Creek (OC-5) and Cabbage Creek (CC-3) also showed satisfactory physical and chemical water quality. In fact, the chloride and total solids concentrations are approximately eight and three times lower respectively than the main stem of the Oklawaha.

The chloride concentration in the Oklawaha River near the Rodman Dam site averaged 74 ppm. When the St. Johns Lock is completed and placed into operation, waters from the St. Johns River will be interchanged with the Oklawaha River in the Rodman pool. The chloride concentration in the St. Johns River at Palatka during the survey period averaged 190 ppm. While sufficient data are not available to make definitive predictions, the possibility of detrimental effect to fresh water aquatic life due to increased salinity in the Rodman pool should be observed by the installation of a chloride and/or conductivity monitor at the pool entrance to the lock.

2) Withlacoochee River

As with the Oklawaha River, water quality in the Withlacoochee River was excellent during the pre-impoundment survey. Figures IV and V present the water quality profiles. Dissolved oxygen upstream of Inglis Lake and in Blue Run tributary averaged 7.0 ppm. The five-day B.O.D. observed

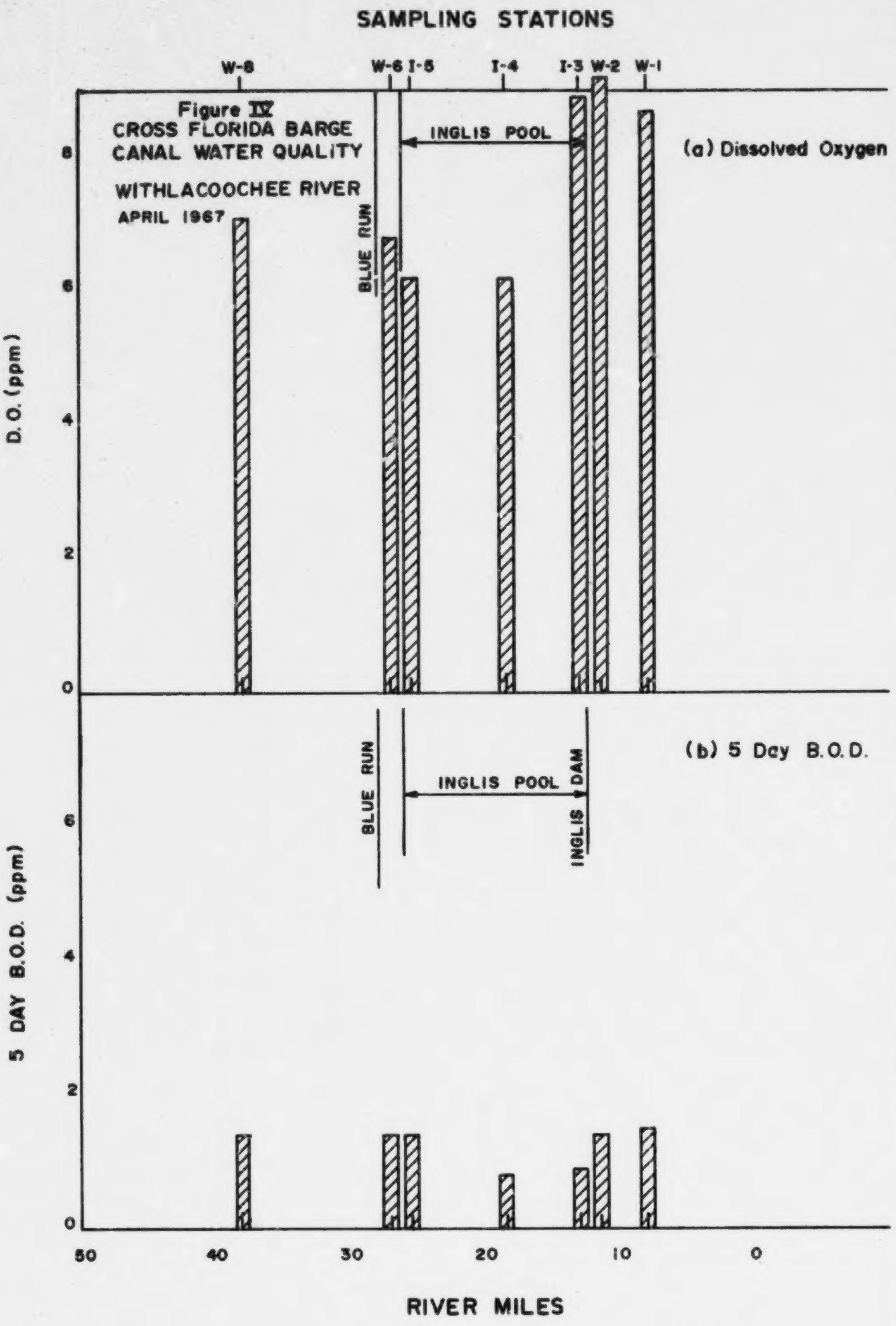


Figure IV
CROSS FLORIDA BARGE CANAL WATER QUALITY
WITHLACOOCHEE RIVER
APRIL 1967

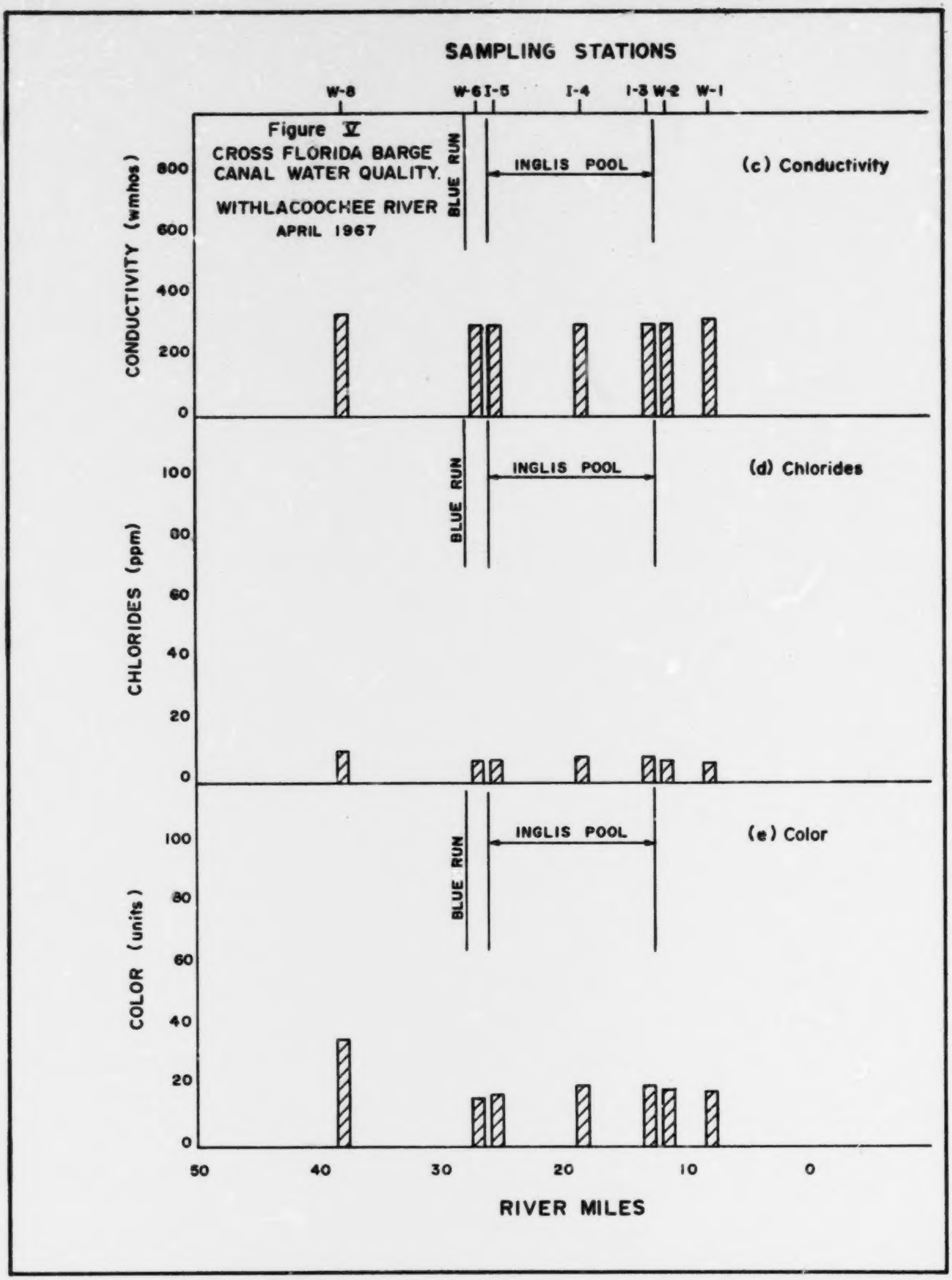


Figure V
CROSS FLORIDA BARGE CANAL WATER QUALITY.
WITHLACOOCHEE RIVER
APRIL 1967

averaging 1.2 ppm was indicative of a stream unpolluted by point sources of municipal and industrial wastes.

Municipal wastes from a secondary sewage treatment plant at Dunnellon, Florida, (population 1,079) are discharged to the Withlacoochee River just above the headwaters of Inglis Lake. At the first sampling station in the lake below Dunnellon, no deterioration in physical or chemical water quality directly attributable to the waste discharge could be detected.

Samples taken in the main body of Inglis Lake exhibited no dissolved oxygen values lower than 5.6 ppm. There was no essential difference in concentration between surface and bottom samples for any of the parameters measured. This situation was also apparent at Inglis Dam. At this point, the lowest dissolved oxygen value observed was 8.2 ppm. The concentrations of all physical and chemical parameters in Inglis Lake were suitable for both recreational and fishing purposes. Water downstream of the dam is also of very good quality and is not objectionable for contact and non-contact uses.

C. Bacteriological:

The major indicator of bacteriological water quality has traditionally been the coliform organism. Particular species of the coliform group are thought to derive exclusively from the intestines of man and other warm-blooded animals, and the presence of these fecal coliform organisms in water are presumed to be directly indicative of fecal pollution.

Arithmetic mean values of total and fecal coliform on the Oklawaha River and tributaries are illustrated in Figure VI. The maximum observed mean total coliform was 6,910/100 ml at the mouth of Cabbage Creek. In the main stem of the Oklawaha River, densities ranged from 1,612/100 ml below the confluence with the Silver River to 5,030/100 ml at Riverside Landing near the site of Rodman Dam. Total coliform at Silver Springs averaged 2,450/100 ml. Since no discharges of waste, except some insignificant widely separated point sources, are apparent in the study area on the Oklawaha River, it must be concluded that total coliform densities on the Oklawaha River primarily result from natural drainage from low lying areas with a highly organic substrate such as swamp land. Most of the species of coliform are not particular to human or animal wastes but also grow in abundance in soils depending upon nutrients and other environmental conditions. Waters composed primarily of land drainage generally exhibit significant total coliform densities.

Arithmetic average fecal coliform densities showed no significant pollution at most stations on the main stem of the Oklawaha River and at Silver Springs. However, Cabbage Creek

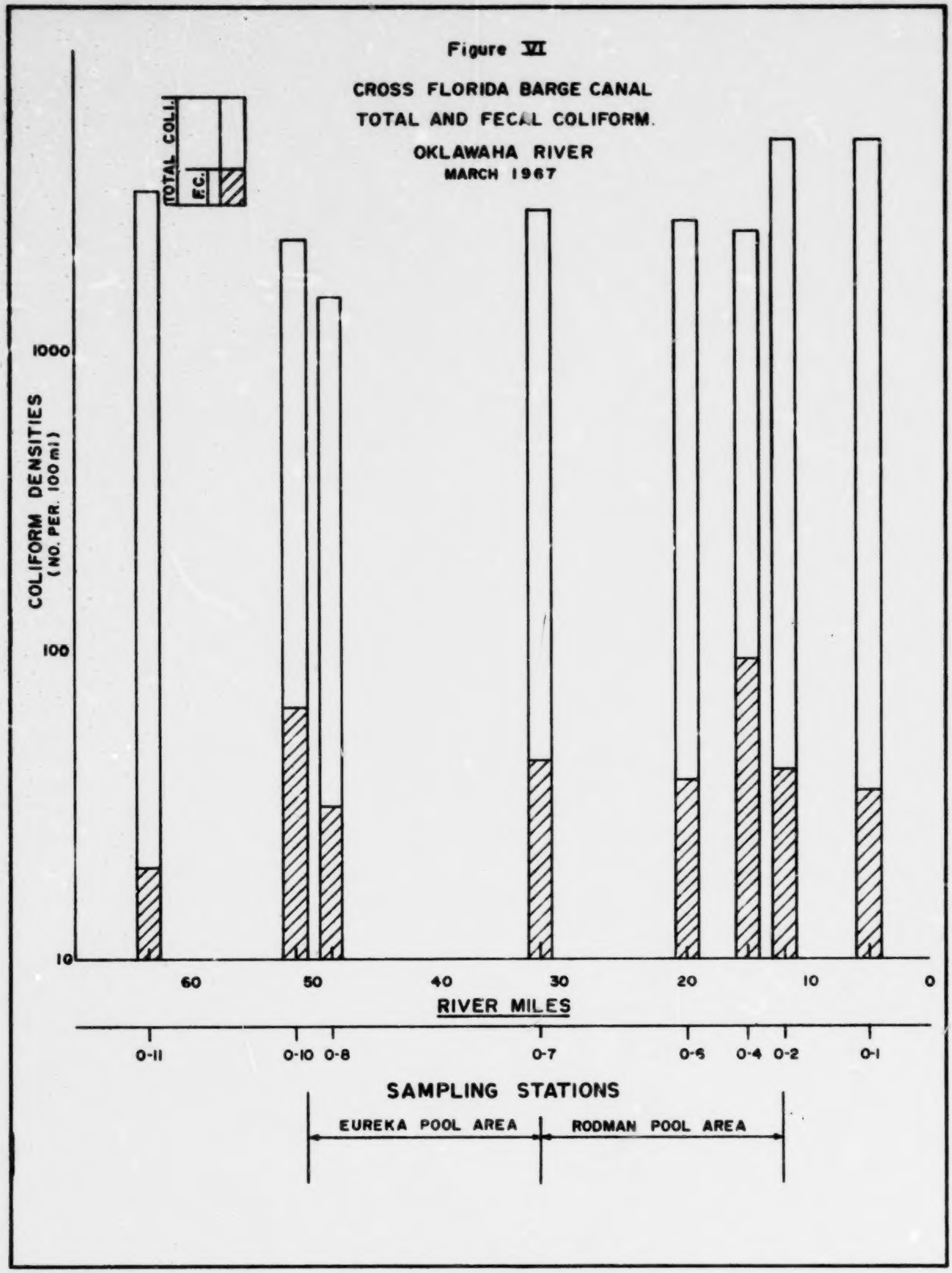


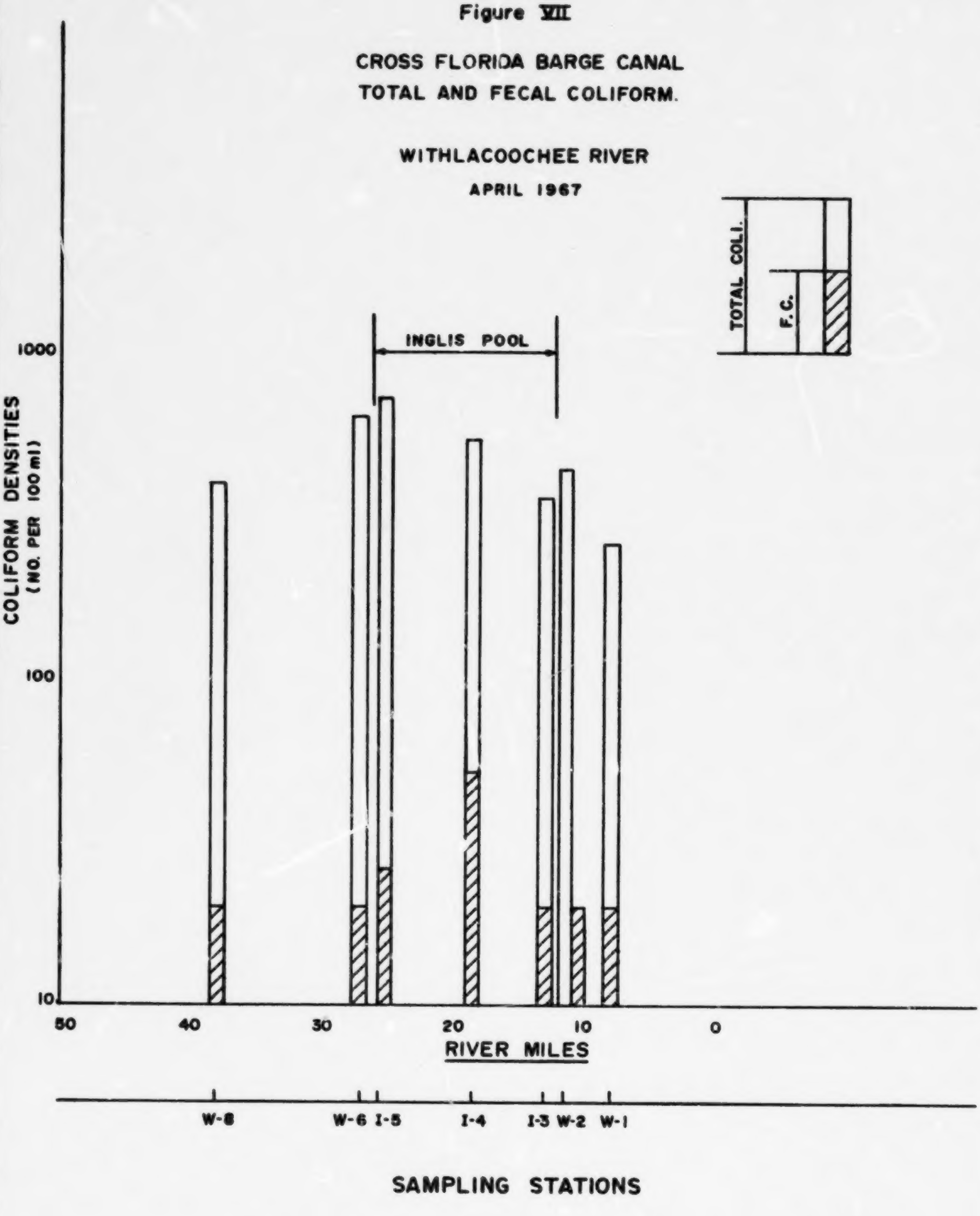
Figure VI

CROSS FLORIDA BARGE CANAL
TOTAL AND FECAL COLIFORM.
OKLAWAHA RIVER
MARCH 1967

Figure VII

CROSS FLORIDA BARGE CANAL
TOTAL AND FECAL COLIFORM.

WITHLACOOCHEE RIVER
APRIL 1967



had an observed fecal coliform average density of 164/100 ml with a maximum value of 330/100 ml. Orange Creek showed a maximum value of 170/100 ml although the average density was 84/100 ml. Cabbage Creek had an average total coliform density of 6,910/100 ml which is greater than all of the upstream stations on the Oklawaha River. The Oklawaha River in this area was affected by waste discharges on these tributaries as is shown by a maximum value of 3,300/100 ml observed at Cedar Landing (0-4). All of these areas will be within the impoundment created by Rodman Dam. The village of Interlachen (pop. 350) discharging to Gem Creek, a tributary of Cabbage Creek, is the most significant point source of pollution in the Rodman pool area. The other sources of wastes are mostly fishing camps and may be eliminated by construction of the canal. Interlachen should provide effective treatment and disinfection and the commercial establishments in and around Orange Springs should provide adequate treatment and disinfection to their wastes before discharge. Total coliform densities of 5,030/100 ml and 4,920/100 ml were observed at the Rodman Dam site (0-2) and the Route 19 bridge (0-1) respectively. Fecal coliform concentrations at these locations had maximum observed values of 80/100 ml.

The Withlacoochee River exhibited average total coliform densities below 1,000/100 ml at all stations sampled.

Total and fecal coliform profiles are given in Figure VII. The maximum observed total coliform density was 1,700/100 ml in Inglis Lake. The area in and around Dunnellon (W-6 and I-5) showed higher total coliform densities than other stations but were acceptable for recreational purposes. The same distribution also was observed for fecal coliform. The maximum fecal coliform density observed in the Withlacoochee system was 170/100 ml below Inglis Dam (W-2). Fecal coliform showed an increase below Dunnellon, but the maximum observed average value was 58/100 ml (I-4-B). Dunnellon discharges chlorinated wastes, and it is probable that these slightly increased coliform densities result from the development of the land in this area.

In general, bacterial pollution is not currently a problem along the proposed route of the Canal except in the area around Orange Springs and Cabbage Creek on the Oklawaha River. It is to be expected that the proposed recreational developments will cause densities to increase slightly due to the increased activity as is shown at Dunnellon. If proper and adequate waste disposal and disinfection facilities are supplied at all sources, bacterial concentrations should remain acceptable for contact recreation.

33-A

V) DREDGING

Extensive dredging operations will be necessary in the construction and subsequent maintenance of the Cross Florida Barge Canal. The disposal of this dredged material may have serious biological consequences if improper spoil sites are selected. Spoil disposal sites in water, because of the disturbance of dredging and redeposit, will have an adverse effect on water quality with regard to turbidity, solids and organic demand if protective measures are not taken. In general, spoil disposal in water, and particularly in shallow water areas, will destroy valuable fish breeding and feeding areas. For these reasons, spoil should be disposed on upland areas wherever possible.

Representatives of FWPCA in company with other agencies have inspected the proposed spoil sites on the stretch of canal between Dunnellon Lock and Inglis Lock. Most of this area is presently inundated by Inglis Lake, which is heavily utilized for fishing and the dredging material will result from the construction of a navigation channel through this lake. All of the spoil sites originally selected by the Corps of Engineers were in shallow or open water areas. As a result of this inspection, some of the construction spoil sites have been tentatively moved to upland areas. However, due to economic considerations listed by the Corps of Engineers, all of the maintenance spoil sites presently remain in shallow or open water areas of Inglis Reservoir even though some have been tentatively shifted from their original location. A similar situation has recently been proposed for the Rodman pool.

It is strongly recommended that spoil be disposed to upland areas along the entire length of the canal. Where this is not possible, all fill areas in water should be diked and weired to permit a minimum of disturbance to the existing water quality. The dikes should be constructed by dragline rather than pumping and filling should progress from the upland side of the fill area.

The intermediate phase of this FWPCA study will observe and evaluate the above recommended control procedures. Periodic inspections of the dredge and fill sites will continue throughout the project. Samples will be taken to determine the amount of materials suspended in the immediate dredging areas and the transfer and redeposit of these solids in other areas.

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VI) HYACINTHS

Water hyacinths are presently prevalent in both Inglis Lake and the impoundment behind Moss Bluff Dam. Hyacinths are ubiquitous in both river systems when the waters become impounded. The accompanying biological report concludes that the nutrient content of the water in both systems is sufficient to produce hyacinth blooms in the newly impounded areas particularly in the Oklawaha River. While a certain amount of hyacinths are beneficial as fish spawning and feeding areas, the major recreational uses of boating and swimming will require a control program for safety and general aesthetic purposes. This program should consist of mechanical means of control and the organic material should be harvested and removed from the system. If the material is not harvested, the subsequent decay in the impoundment will cause severe deterioration of water quality with pronounced detrimental effects on uses in a short term period. In addition, the nutrients which are released in slug quantities may accelerate the cycle of eutrophication resulting in a loss of projected long term benefits.

APPENDIX

SUMMARY OF OBSERVED DATA

36-A

TABLE A-1

CROSS FLORIDA BARGE CANAL - SUMMARY OF OBSERVED DATA

A) Oklawaha River and Tributaries

March-April 1967

STATION		TOTAL COLIFORM No./100 ml	FECAL COLIFORM No./100 ml	TEMP. °C	D. O. ppm	5-Day BOD ppm	2-Day BOD ppm	TOTAL SOLIDS ppm	VOLATILE SOLIDS ppm	CONDUCTIVITY µ MHOS	CHLORIDES ppm
0-1	Average	4920	36			1.97	1.34				
	Maximum	11000	80			4.80	3.70				
	Minimum	2300	20			1.10	0.10				
0-2	Average	5030	41	20.5	6.6	1.58	1.07	375	7	583	74
	Maximum	17000	80	22.0	7.0	2.40	2.20	415	10	650	81
	Minimum	700	20	19.0	6.0	1.20	1.00	305	5	540	69
CC-3	Average	6910	164	21.5	7.8	1.66	.96	135	8	170	7
	Maximum	24000	330	20.0	8.6	3.30	1.90	185	15	200	8
	Minimum	1700	80	18.0	7.3	.70	0.50	95	5	152	7
0-4	Average	2480	97	20.4	7.2	2.13	1.45	280	5	485	51
	Maximum	4600	3300	21.0	7.8	7.50	4.90	345	5	550	55
	Minimum	1100	20	20.0	6.6	.60	.40	170	5	445	49
OC-5	Average	2110	84	18.7	8.2	1.50	1.01	100	5	109	10
	Maximum	7000	170	20.0	8.9	2.60	1.90	125	5	120	11
	Minimum	790	20	17.0	7.7	0.90	0.10	65	5	96	9
0-6	Average	2730	39	20.8	7.4	1.66	1.06	374	5	561	60
	Maximum	11000	60	22.0	7.8	4.50	3.30	400	5	615	78
	Minimum	600	20	20.0	6.9	.50	0.40	325	5	550	60
0-7	Average	2930	45	21.7	7.4	1.29	0.87	273	5	405	15
	Maximum	13000	80	22.0	7.7	2.70	2.00	305	5	435	50
	Minimum	2100	20	21.0	6.9	0.50	0.10	235	5	390	9

Oklawaha River and Tributaries (Cont'd)

STATION		TOTAL COLIFORM No./100 ml	FECAL COLIFORM No./100 ml	TEMP. °C	D. O. ppm	5-Day BOD ppm	2-Day BOD ppm	TOTAL SOLIDS ppm	VOLATILE SOLIDS ppm	CONDUC-TIVITY µ MHOS	CHLORIDES ppm
0-8	Average	1612	32	22.0	4.8	1.57	0.97	262	5	405	14
	Maximum	4900	80	22.0	5.6	2.30	2.20	290	5	440	36
	Minimum	230	20	21.0	4.1	0.80	0.30	235	5	375	9
SS-9	Average	2450	23	21.7	3.9	1.29	0.82	274	5	422	9
	Maximum	3300	50	22.0	5.0	2.20	1.80	305	5	460	10
	Minimum	230	20	21.0	3.2	0.70	0.20	245	5	405	8
0-10	Average	2360	67	20.1	6.5	2.99	1.42	224	5	291	19
	Maximum	7900	80	22.0	7.0	4.30	2.10	245	5	315	21
	Minimum	460	20	19.0	6.3	1.90	1.00	205	5	284	18
0-11	Average	3410	20	19.5	7.7	3.92	1.73	222	6	297	20
	Maximum	7900	20	20.0	8.0	5.60	2.70	270	10	320	22
	Minimum	940	20	18.0	7.5	3.00	1.20	195	5	280	18

TABLE A-1

CROSS FLORIDA BARGE CANAL - SUMMARY OF OBSERVED DATA

A) Oklawaha River and Tributaries
March-April 1967

STATION		COLOR (UNITS)	pH	ALKA-LINITY (ppm)	HARDNESS (ppm)	SULFATE (SO_4) ppm	IRON (Fe) ppm	MANGANESE (Mm) ppm	ORGANIC NITROGEN (N) ppm	NH_3-N ppm	NO_2+NO_3 (N) ppm	TOTAL PO_4 ppm	SOLUBLE PO_4 ppm
0-1	Average	54				0.48	0.5	0.0	0.97	0.02	0.46	0.21	0.17
	Maximum	60											
	Minimum	45											
0-2	Average	53	7.4	105	174	0.53	0.5	1.0	0.74	0.02	0.24	0.30	0.19
	Maximum	60	7.6	108	180								
	Minimum	45	7/3	102	170								
CC-3	Average	48	7.3	67	70	0.07	0.5	0.5	0.70	0.10	0.01	0.17	0.11
	Maximum	55	7.5	72	71								
	Minimum	30	7.1	62	68								
0-4	Average	35	7.5	112	168	0.51	0.0	0.5	1.15	0.15	0.28	0.22	0.18
	Maximum	40	7.7	118	180								
	Minimum	30	7.4	109	150								
OC-5	Average	88	6.8	26	31	0.05	0.5	0.0	1.87	0.07	0.12	0.17	0.14
	Maximum	95	7.1	30	37								
	Minimum	80	6.4	24	29								
0-6	Average	25	7.6	129	200	0.65	0.0	0.0	0.56	0.11	0.39	0.16	0.15
	Maximum	30	7.7	135	210								
	Minimum	20	7.5	126	170								
0-7	Average	21	7.7	134	184	0.42	0.5	0.0	0.57	0.12	0.44	0.18	0.14
	Maximum	25	7.8	136	190								
	Minimum	15	7.6	130	170								

Oklawaha River and Tributaries (Cont'd)

STATION		COLOR (UNITS)	pH	ALKA-LINITY (ppm)	HARDNESS (ppm)	SULFATE (SO_4) ppm	IRON (Fe) ppm	MANGANESE (Mm) ppm	ORGANIC NITROGEN (N) ppm	NH_3-N ppm	NO_2+NO_3 (N) ppm	TOTAL PO_4 ppm	SOLUBLE PO_4 ppm
0-8	Average	17	7.5	134	182	0.41	0.0	0.0	1.14	0.16	0.57	0.20	0.13
	Maximum	20	7.6	136	190								
	Minimum	15	7.4	131	180								
SS-9	Average	5	7.5	152	198	0.50	0.0	0.0	1.41	0.12	0.54	0.20	0.16
	Maximum	5	7.6	155	210								
	Minimum	5	7.3	148	190								
0-10	Average	98	7.2	87	106	0.22	1.5	0.0	2.82	0.17	0.08	0.14	0.08
	Maximum	130	7.4	93	110								
	Minimum	80	7.1	82	100								
0-11	Average	57	7.2	92	110	0.15	0.5	0.5	4.61	0.18	0.05	0.11	0.06
	Maximum	60	7.3	95	110								
	Minimum	50	7.0	89	110								

TABLE A-1

CROSS FLORIDA BARGE CANAL - SUMMARY OF OBSERVED DATA
B) Withlacoochee River and Tributaries
March-April 1967

STATION		TOTAL COLIFORM No./100 ml	FECAL COLIFORM No./100 ml	TEMP. °C	D. O. ppm	5-Day BOD ppm	2-Day BOD ppm	TOTAL SOLIDS ppm	VOLATILE SOLIDS ppm	CONDUC-TIVITY µ MHOS	CHLORIDES ppm
W-1	Average	260	20	23	8.7	1.5	0.8	184	5	317	6
	Maximum	490	20	25	9.0	2.7	1.0	200	5	330	8
	Minimum	110	20	21	8.2	0.8	0.2	180	5	284	4
W-2	Average	440	20	23	9.2	1.4	1.0	171	5	299	7
	Maximum	790	170	25	9.9	1.9	1.3	180	5	308	8
	Minimum	110	20	21	8.6	1.0	0.7	160	5	280	7
I-3-T	Average	330	20	24	8.9	1.0	0.7	188	5	300	7
	Maximum	500	20	25	9.9	1.3	1.2	220	5	312	8
	Minimum	110	20	22	8.2	0.5	0.5	175	5	281	7
I-3-B	Average	410	20	24	8.9	0.8	0.6	180	5	299	8
	Maximum	790	20	25	9.8	1.3	1.0	195	5	308	9
	Minimum	110	20	22	8.3	0.3	0.1	170	5	284	7
I-4-T	Average	460	45	23	6.3	0.6	0.4	174	5	298	8
	Maximum	790	80	24	6.6	1.1	1.0	195	5	308	7
	Minimum	170	20	22	5.9	0.3	0.1	165	5	286	7
I-4-B	Average	610	58	24	6.2	0.9	0.4	176	5	301	7
	Maximum	1700	130	29	6.7	2.1	0.6	200	5	308	8
	Minimum	230	20	22	5.6	0.7	0.1	165	5	274	7
I-5	Average	710	26	24	6.2	1.4	0.7	172	5	302	7
	Maximum	1300	50	25	7.0	2.9	1.5	180	5	314	8
	Minimum	330	20	23	5.8	0.9	0.1	165	5	288	7

Withlacoochee River and Tributaries (Cont'd)

STATION		TOTAL COLIFORM No./100 ml	FECAL COLIFORM No./100 ml	TEMP. °C	D. O. ppm	5-Day BOD ppm	2-Day BOD ppm	TOTAL SOLIDS ppm	VOLATILE SOLIDS ppm	CONDUC-TIVITY u MHOS	CHLORIDES ppm
W-6	Average	630	20	24	6.8	1.4	0.8	174	5	299	7
	Maximum	1300	20	25	7.2	1.7	1.1	180	5	314	8
	Minimum	230	20	22	6.3	0.6	0.5	170	5	279	7
BR-7	Average	280	20	22	7.0	1.9	0.7	149	6	264	5
	Maximum	490	80	24	10.2	2.8	1.5	155	10	277	6
	Minimum	80	20	22	6.3	0.5	0.3	145	5	247	5
W-8	Average	390	20	24	7.1	1.4	0.7	216	5	334	10
	Maximum	790	20	26	8.2	2.6	1.5	235	5	352	11
	Minimum	130	20	22	6.8	0.5	0.2	205	5	314	9

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TABLE A-1

CROSS FLORIDA BARGE CANAL - SUMMARY OF OBSERVED DATA
B) Withlacoochee River and Tributaries
March-April 1967

STATION		COLOR (UNITS)	pH	ALKA-LINITY (ppm)	HARDNESS (ppm)	SULFATE (SO_4) ppm	IRON (Fe) ppm	MANGANESE (Mm) ppm	ORGANIC NITROGEN (N) ppm	NH_3-N ppm	NO_2+NO_3 (N) ppm	TOTAL PO_4 ppm	SOLUBLE PO_4 ppm
W-1	Average	18	7.8	111	128	0.11	1.5	0.5	0.58	0.03	0.04	0.12	0.10
	Maximum	20	7.8	117	130								
	Minimum	15	7.7	110	120								
W-2	Average	19	7.9	103	126	0.11	2.0	1.0	0.53	0.02	0.03	0.12	0.10
	Maximum	20	8.0	105	130								
	Minimum	15	7.7	101	120								
I-3-T	Average	20	7.8	104	126	0.10	1.0	1.0	0.62	0.02	0.03	0.11	0.08
	Maximum	20	8.0	105	120								
	Minimum	20	7.7	102	130								
I-3-B	Average	20	7.8	107	130	0.11	2.5	0.5	0.54	0.03	0.03	0.13	0.09
	Maximum	20	8.1	111	130								
	Minimum	20	7.7	105	130								
I-4-T	Average	20	7.4	107	130	0.12	2.0	1.0	0.43	0.02	0.06	0.13	0.11
	Maximum	20	7.5	110	130								
	Minimum	20	7.3	106	130								
I-4-B	Average	20	7.4	109	126	0.12	2.0	0.5	0.27	0.06	0.07	0.15	0.13
	Maximum	20	7.5	113	130								
	Minimum	20	7.3	105	120								
I-5	Average	17	7.5	110	130	0.14	0.5	0.0	0.55	0.03	0.20	0.45	0.13
	Maximum	20	7.7	114	130								
	Minimum	15	7.4	104	130								

Withlacoochee River and Tributaries (Cont'd)

STATION		COLOR (UNITS)	pH	ALKA-LINITY (ppm)	HARDNESS (ppm)	SULFATE (SO_4) ppm	IRON (Fe) ppm	MANGANESE (Mm) ppm	ORGANIC NITROGEN (N) ppm	NH_3-N ppm	NO_2+NO_3 (N) ppm	TOTAL PO_4 ppm	SOLUBLE PO_4 ppm
W-6	Average	16	7.6	106	128	0.11	1.0	0.0	0.33	0.01	0.21	0.14	0.11
	Maximum	20	7.7	109	130								
	Minimum	15	7.6	102	120								
BR-7	Average	5	7.7	96	112	0.06	0.5	0.0	0.12	0.00	0.41	0.16	0.12
	Maximum	5	8.1	97	120								
	Minimum	5	7.5	94	110								
W-8	Average	35	7.6	114	144	0.18	1.5	0.0	0.55	0.04	0.07	0.10	0.07
	Maximum	35	7.7	116	150								
	Minimum	35	7.5	111	140								

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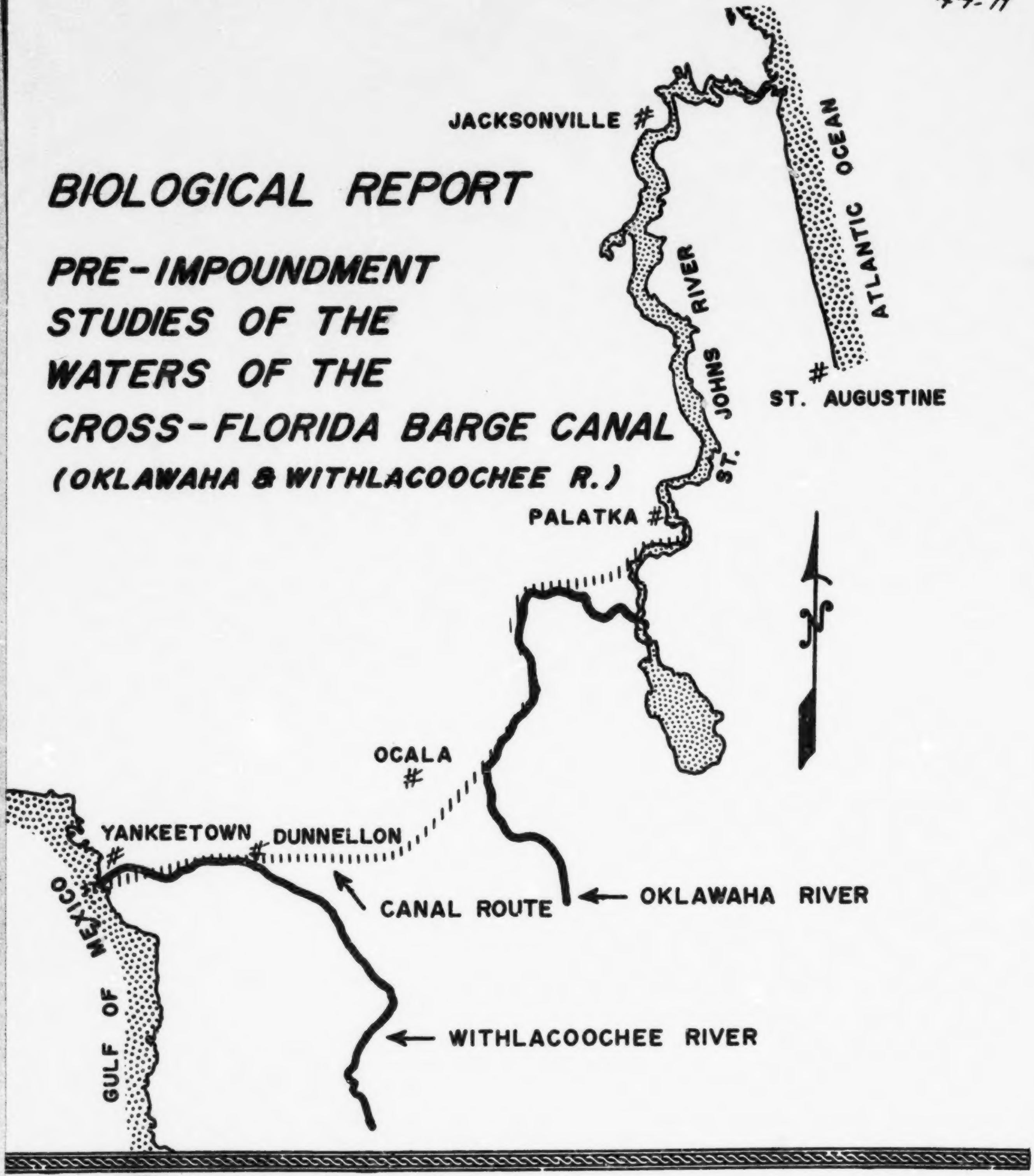
BIOLOGICAL REPORT

PRE-IMPOUNDMENT STUDIES OF THE WATERS OF THE CROSS-FLORIDA BARGE CANAL

(OKLAWAHA & WITHLACOOCHEE R.)


JACKSONVILLE
ATLANTIC OCEAN
ST. JOHNS RIVER
ST. AUGUSTINE
PALATKA
OCALA
YANKEETOWN
DUNNELLON
CANAL ROUTE
OKLAWAHA RIVER
GULF OF MEXICO
WITHLACOOCHEE RIVER

March 3, 1849

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

SOUTHEAST WATER LABORATORY
ATHENS, GEORGIA

TECHNICAL ADVISORY AND
INVESTIGATIONS BRANCH
CINCINNATI, OHIO

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SUMMARY & CONCLUSIONS

I. Biological studies revealed that water quality is excellent in the Oklawaha and Withlacoochee rivers. The waters can be used for a wide variety of uses except the reach of the Oklawaha River extending from the confluence (River Mile 44.9) of Silver River upstream; here the sluggish nutrient rich waters support planktonic algae in quantities that might interfere with use of the waters as a water supply and reduce the aesthetic values sufficiently to interfere with swimming and wading.

II. Construction of the canal was degrading water quality in localized areas. The downstream most twenty miles of the Oklawaha River carried suspended silts and organic materials, added to the water by dredging and land clearing operations, that reduced algal growths and changed bottom animal populations resulting in reduced available fish food supplies. This problem is temporary and will cease with completion of construction.

III. Following completion of the canal system several changes and problems may be encountered in the waterways. These are as follows:

(a.) The joining of the Oklawaha and Withlacoochee river systems will facilitate the migration of the asiatic clam, Corbicula, from the Gulf streams to the waterways of the Atlantic coast. As of now, this potential pest organism has not been reported in the river systems draining to the Atlantic Ocean.

(b.) The change from free-flowing waters to impounded slack waters will produce changes in the fish fauna. Fish populations will shift towards the type encountered in lakes. Initially there will be an increase in fish production because the flooding of virgin lake bottoms will temporarily increase the amount of nutrients and food in relation to both the area and volume of water. Once this "fish-food" supplement is exhausted, the initially stimulated fishery will decline to a lower level based on the nutrients and foods available within the aquatic ecosystem.

(c.) Impoundment of the waters will create changes in the bottom animal populations. The numbers of potential nuisance organisms such as mosquitoes and midges will increase because of a change to an environment that is more conducive to their propagation. The slack backwaters will serve as breeding areas for mosquitoes. Organic materials, that are now swept away by currents, will settle to the lake bottoms and accumulate to provide food for increased numbers of midge larvae.

(d.) Aquatic vegetation will be a problem. This problem will be much more evident in the Oklawaha watershed, because nutrient concentrations are higher here than in the Withlacoochee watershed. In the slack waters the development of vegetation will proceed in either of two directions:

1. Water hyacinths may develop into dense populations. Once established the hyacinths have a potential of becoming the dominant aquatic plant because the dense mats formed by the plants prevent the penetration of sunlight required for the growth of suspended and bottom attached flora. Masses of water hyacinths are a severe problem because they interfere with most water uses including navigation, fishing, swimming, and recreational boating; present control methods are not adequate.
2. If water hyacinths do not develop into the dominant form of aquatic vegetation, it is likely that dense blooms of algae will develop. These blooms already occur in the upstream sluggish reaches of the Oklawaha River. The waters discharged to the river from Silver Springs contain sufficient phosphorus to increase the concentrations in the river by more than 200 percent. In contrast to phosphorus, the nitrogen concentrations decrease after the addition of Silver Springs water. This combination of fertilizers will give the blue-green algae, which are presently the predominant form in the upstream reaches of the Oklawaha, a competitive advantage because of their capability to utilize atmospheric or gaseous nitrogen as a nutrient. A predominantly blue-green algal plankton community is accompanied by more problems than one composed of other or a variety of forms because of the tendency for blue-greens to

form floating mats and windrows that are aesthetically unpleasant, produce undesirable taste and odors in the waters, and upon death of accumulations of these algae pig-pen odors are generated by the decomposition of the mass. The increases in aquatic vegetation in the impounded waters will restrict and reduce the potential uses of these waters.

(e.) The use of waters by commercial navigation is accompanied by an increase in pollution potential. Large volumes of hazardous materials, such as oils, acids, toxic chemicals, etc., are transported by barges. Navigation accidents that rupture vessels, bilge pumping, leaking cargoes, washing and cleaning of barges are examples of ways that significant quantities of pollutants may enter the waterway. Policing and enforcement of strict safety, navigation and water pollution control regulations will be necessary to prevent contamination of the high quality waters of the Withlacoochee and Oklawaha rivers.

INTRODUCTION

Upon completion of construction by the Corps of Engineers, the 107 mile-long Cross-Florida Barge Canal will shorten the route of shipping between the Mississippi River-Gulf of Mexico waterways and the Intracoastal Waterway of the Atlantic seaboard. Beginning at the western Gulf of Mexico terminus, near Yankeetown, Florida, the canal will approximate the course of the Withlacoochee River upstream to Dunnellon, Florida, from where it will traverse cross-country in a northeasterly direction until it intercepts the Oklawaha River near Ocala, Florida, after which it generally follows the course of the Oklawaha River to its eastern terminus on the navigable St. Johns River near Palatka, Florida (see cover). The purpose of this study was to ascertain the existing water quality and predict water quality changes that may occur in these rivers as a result of changes in the nature of the rivers and operation of the canal.

WITHLACOOCHEE RIVER

The Withlacoochee River arises in a lake district northeast of Tampa, Florida, and flows North to near Dunnellon where it turns to the West and discharges to the Gulf of Mexico. Blue Run, a major tributary, originates at Rainbow Springs and discharges a large volume of excellent quality water into the Withlacoochee River at Dunnellon. Inglis Dam, a hydroelectric facility (River Mile 10.5), impounds the river to form Lake Inglis that extends upstream to near Dunnellon. In most areas the river's waters are swift and very clear, but are naturally "black-waters" because of the lignins and tannins derived from the low swamp lands of the watershed.

Aquatic Vegetation and Nutrients

The waterway's vegetation may be divided into four components: 1) free-floating suspended algae (plankton), 2) attached algae (periphyton), 3) submerged flowering aquatic plants (pond-weeds), 4) floating surface plants (water hyacinths and duck weeds). Principal factors that govern the growth of these plants are light, temperature, fertilizing nutrients, and suitable substrates for those forms that are attached.

The concentrations of nutrients in the Withlacoochee River waters were low. Total phosphorus (P) was generally less than 40 micrograms per liter. This value is probably near that which occurs in the ground waters of this basin because this value was also observed in Blue Run (Rainbow Springs). Waste waters from Dunnellon increased the phosphorus concentrations (maximum observed, 190 micrograms per liter) in the river, but after a short passage in the river and into the headwaters of Lake Inglis, the growing plants had reduced the phosphorus concentrations to 26 micrograms per liter (Figure 1).

Total nitrogen (N) concentrations were also very low in the Withlacoochee River. The concentrations were always less than 800 micrograms per liter. Blue Run (Rainbow Springs) water had exceptionally low concentrations of

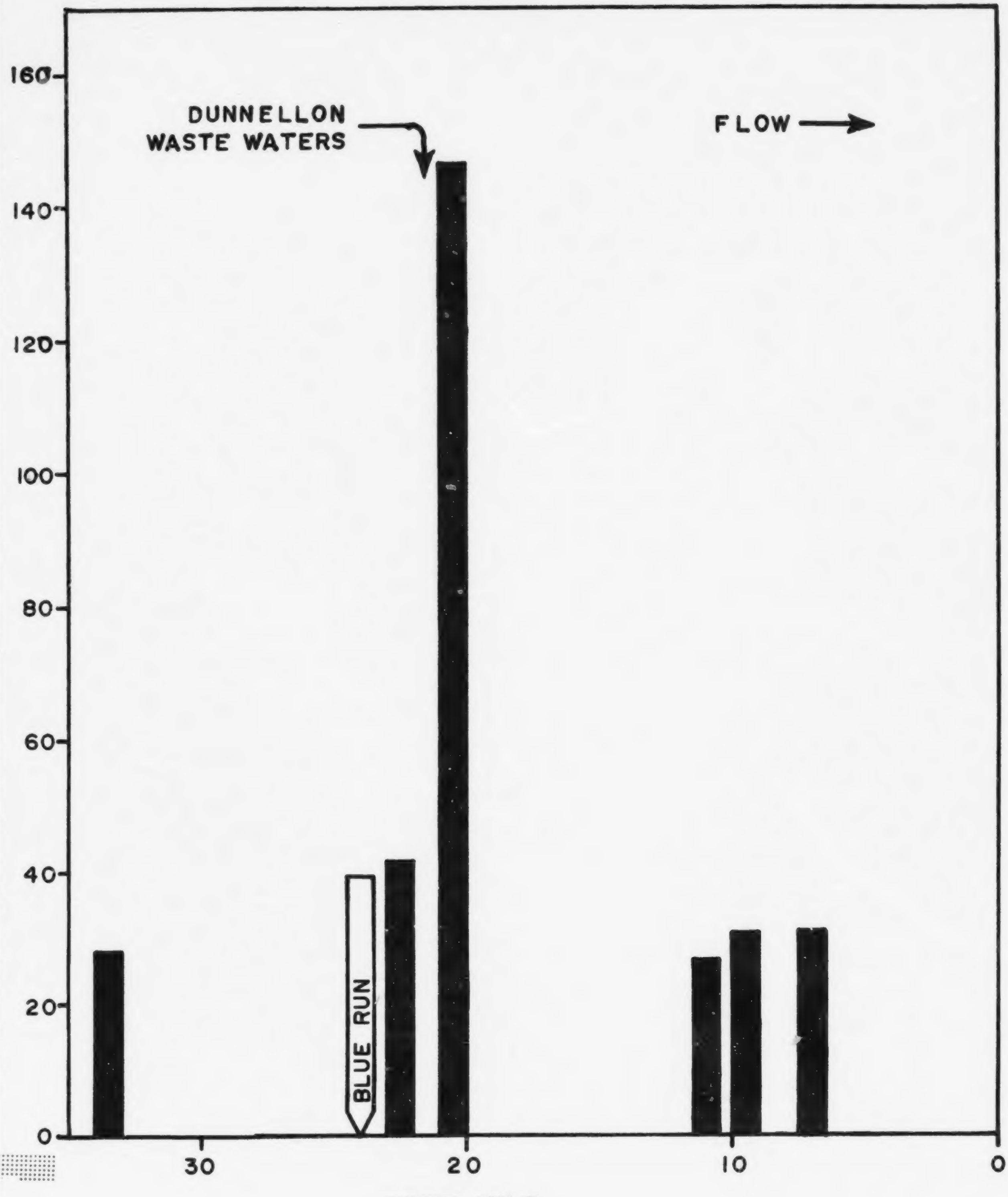


FIGURE 1. TOTAL PHOSPHORUS CONCENTRATIONS IN THE WITHLACOOCHEE RIVER, FLORIDA

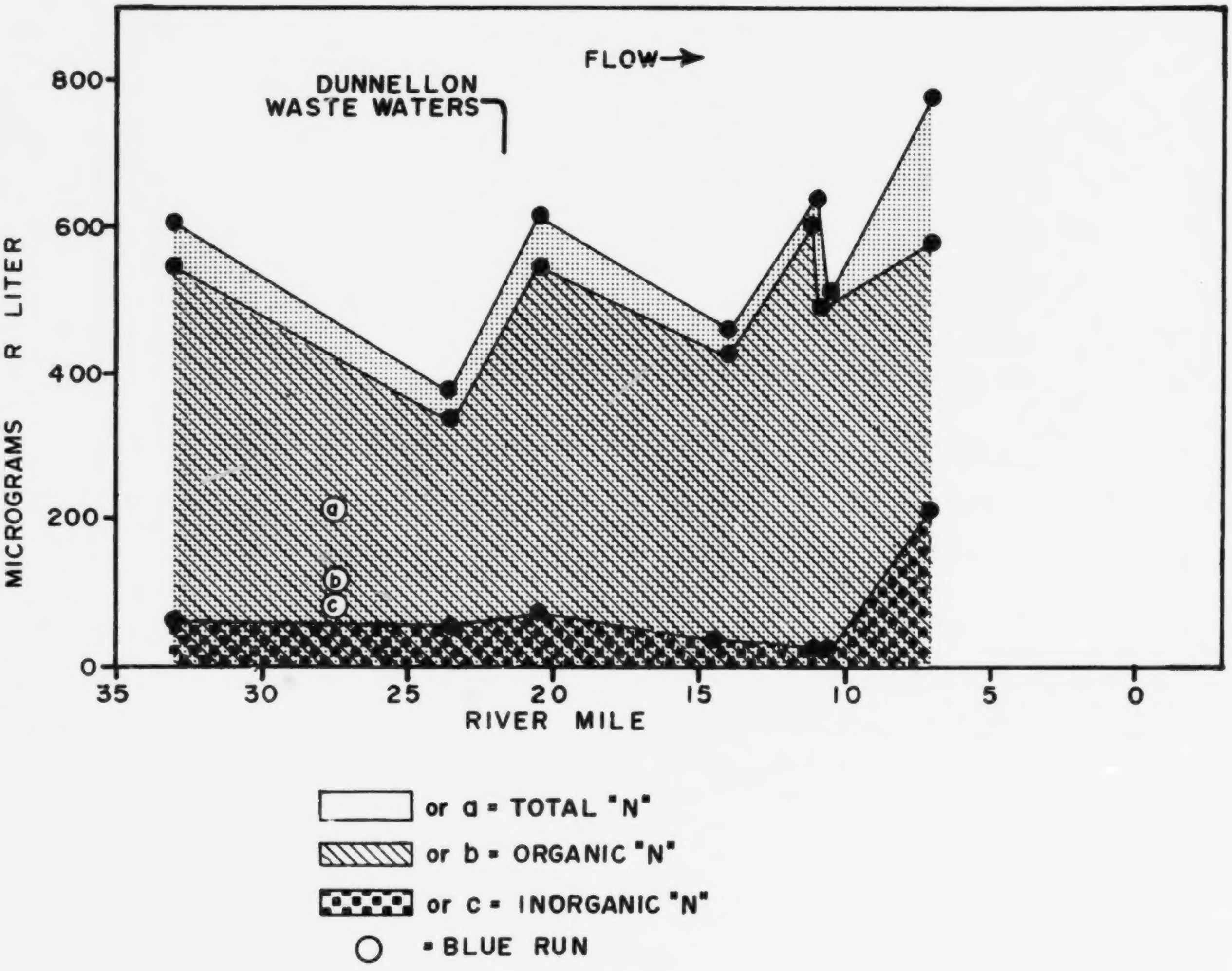
IV) WATER QUALITY

The preimpoundment survey to determine water quality levels prior to major project construction in the impoundment areas was conducted by FWPCA personnel during March and April 1967. These studies consisted of hydrological, chemical, bacteriological and biological analyses of samples collected at twenty-one stations in the Oklawaha and Withlacoochee basins. Analysis of samples was conducted according to procedures listed in the twelfth edition of Standard Methods for the Examination of Water and Wastewater. The sampling stations were chosen to complement the extensive ground water network developed by the U. S. Geological Survey. A description of the sampling stations is contained in Table I and the study area is shown in Figure I. A summary of data follows the discussion. A special biological survey was conducted by staff of the Technical Advisory and Investigations Branch, FWPCA, Cincinnati, Ohio. This report is appended.

A. Hydrology:

1) Oklawaha River

The Oklawaha River originates from the drainage of a series of lakes located generally between Orlando and Ocala, Florida. Drainage is regulated at Moss Bluff by a Corps of Engineers lock and dam. The water quality studies discussed in this report were conducted below Moss Bluff Dam. Immediately prior to the field survey, the Corps began construction to



IGURE 2. CONCENTRATIONS OF NITROGENOUS MATERIALS IN THE WITHLACOOCHEE RIVER, FLORIDA.

being destroyed in the turbulent waters of the tailrace. Nitrogen bound in the hyacinths would not be measured until it was reduced to "particulate," or dissolved forms that would be included in routine water samples.

Water hyacinths are a significant factor in the ecology of this river. Large quantities grow in the slack water areas of the lake and those that border the river in many areas. They are capable of removing large quantities of nutrient materials from the underlying waters. The extensive and dense floating mats formed by the plants restrict the penetration of light into the water which in turn restricts the growth of other forms of aquatic vegetation.

Phytoplankton numbers are very low in both the river and Lake Inglis (Figure 3). The maximum number (1,300 cells per milliliter) and volume (3.2 parts per million) were found a short distance downstream from the source of nutrients at Dunnellon.

Growths of attached algal colonies were very low. In most river areas sampled, less than 1 microgram of chlorophyll per square inch was found in the colonies growing attached to artifical substrates placed in the river for a two-week growing period. Blue Run (Rainbow Springs) samples averaged 12 micrograms of chlorophyll per square inch and samples from the nutrient enriched area near Dunnellon contained 20 micrograms per square inch.

Bottom Animals

The assemblage of invertebrate animals inhabiting the bottom of a waterway is an important indicator of water quality. Being limited in mobility the animals are subjected to variances in the quality of waters

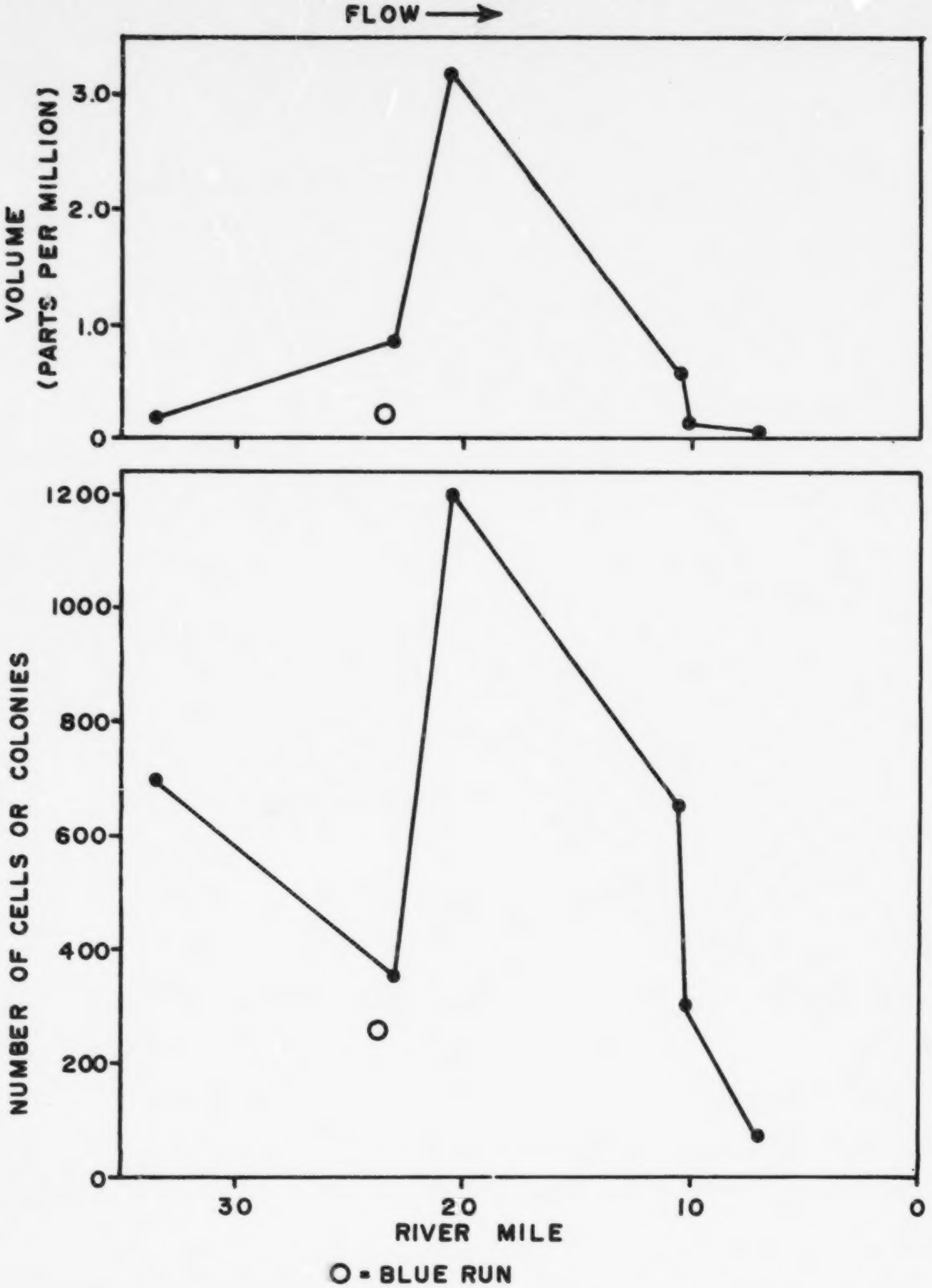


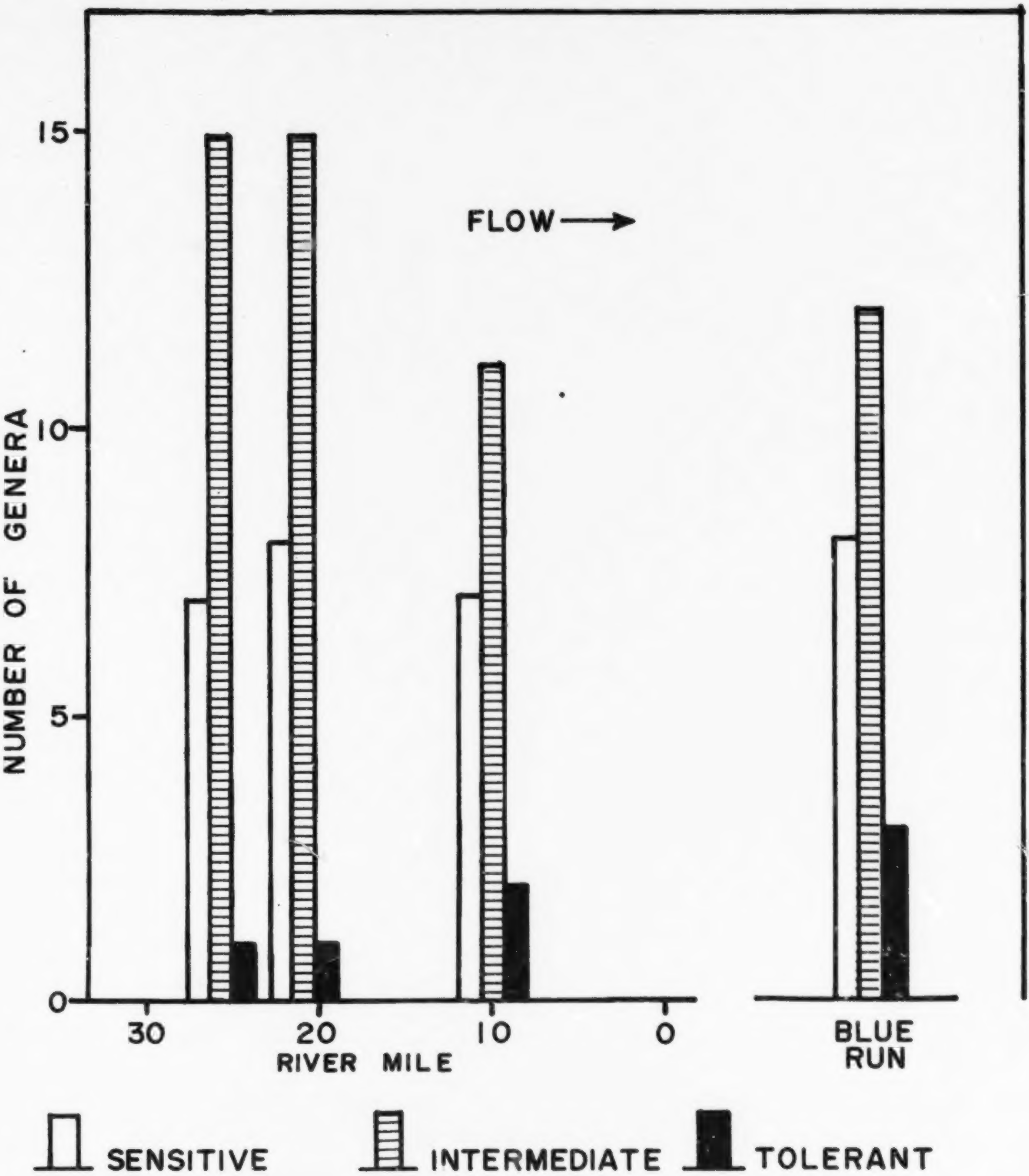
FIGURE 3. PHYTOPLANKTON IN THE WITHLACOOCHEE RIVER, FLORIDA.

passing over them, and being relatively long-lived the animals present and absent reflect the worst water quality conditions imposed on the community during the animal's life-span (for some species in excess of a year).

The bottom animal assemblages found in the Withlacoochee River system were indicative of excellent water quality. The types of animals found did not vary materially at the various stations sampled (Figure 4). Seven or eight pollution-sensitive kinds, such as stoneflies, mayflies, and caddisflies were found at each station. The diversity, twenty or more genera, indicated the waters were of a quality that could support nearly all forms of aquatic life.

An increase in the number of sludgeworms (to 60 per square foot) at the head of Lake Inglis was a response to enrichment of the bottom sediments with organic materials. This is a natural increase because dead plankton and other organic detritus tend to settle in areas such as this where the velocity of the flowing river water is checked.

Notable in the Withlacoochee River system was the large number of imported asiatic clams. These clams are medium sized, up to 1 1/2 inches long, and have been reported to interfere with water systems, including canals where the living clams and shells from dead clams accumulate in sufficient volumes to reduce the cross-sectional area or depth of the canal, thus necessitating more frequent dredging. Live clam populations were as dense as 2,000 per square foot in the lower reaches of the river. Downstream from Inglis Dam the river bottom is naturally sandy over extensive areas.



IGURE 4. THE KINDS OF BOTTOM ANIMALS IN THE WITHLACOOCHEE RIVER, FLORIDA.

This shifting sand is not conducive to the propagation of large quantities of bottom animals that serve as fish food; but the dense populations of asiatic clams have stabilized this bottom and several forms of excellent fish foods live in the niches among the clams, for example 30 mayflies, 10 caddisflies, and 193 scuds per square foot of bottom were found associated with the clams.

OKLAWAHA RIVER

The Oklawaha River originates as drainage from a lake dotted area lying between Ocala and Orlando, Florida. Drainage from this lake-land area is regulated at Moss Bluff by a Corps of Engineers' lock and dam. From Moss Bluff downstream to the confluence of the Silver River the Oklawaha is small and sluggish. Silver Springs discharges via Silver River and this large volume of water increases both the size and velocity of the Oklawaha River.

Aquatic Vegetation and Nutrients

The waters from Silver Springs have a strong influence on the vegetation of the Oklawaha River. Upstream from the confluence phytoplankton predominate, after the clear spring waters enter the system rooted and attached plants become the dominant vegetation. This change is less related to changes in nutrient content, than to the clarity and velocity of the waters.

The concentration of phosphorus in waters discharged at the Moss Bluff Lock and Dam is low (13 to 26 micrograms per liter). The large volume of spring water with a higher total phosphorus concentration (46 to 55 micrograms per liter) increased the concentration in the river (Figure 5). The concentrations then remained relatively constant for the first thirty miles downstream from the spring water confluence, and the concentrations in the two other major tributaries were similar to those in the main stream. In the extreme downstream reaches (Cedar Landing, River Mile 14.3; and Jacksons Landing, River Mile 9.7) concentrations fluctuated and reached levels as high as 104 micrograms per liter. These fluctuations and the increased concentrations are attributable to an increase in suspended sediments that were added to the river by dredging and land clearing in this reach where construction of the canal had already started. These phosphorus bearing sediments were resettled before the waters passed the Rodman Dam site; phosphorus concentrations observed at Highway 19 (River Mile 3.7) were reduced to about 60 micrograms per liter, a value near those observed in unaffected reaches of the river.

Total nitrogen concentrations in the upper reach (Moss Bluff to Silver River Confluence) of the river were extremely high, reaching a maximum of 7,014 micrograms per liter. Here, over 95 percent of the total nitrogen was organic nitrogen. This organic nitrogen was the protein in the large number of algal cells discharged from the fertile upstream lakes via the canal system that terminates at the Moss Bluff Lock and Dam.

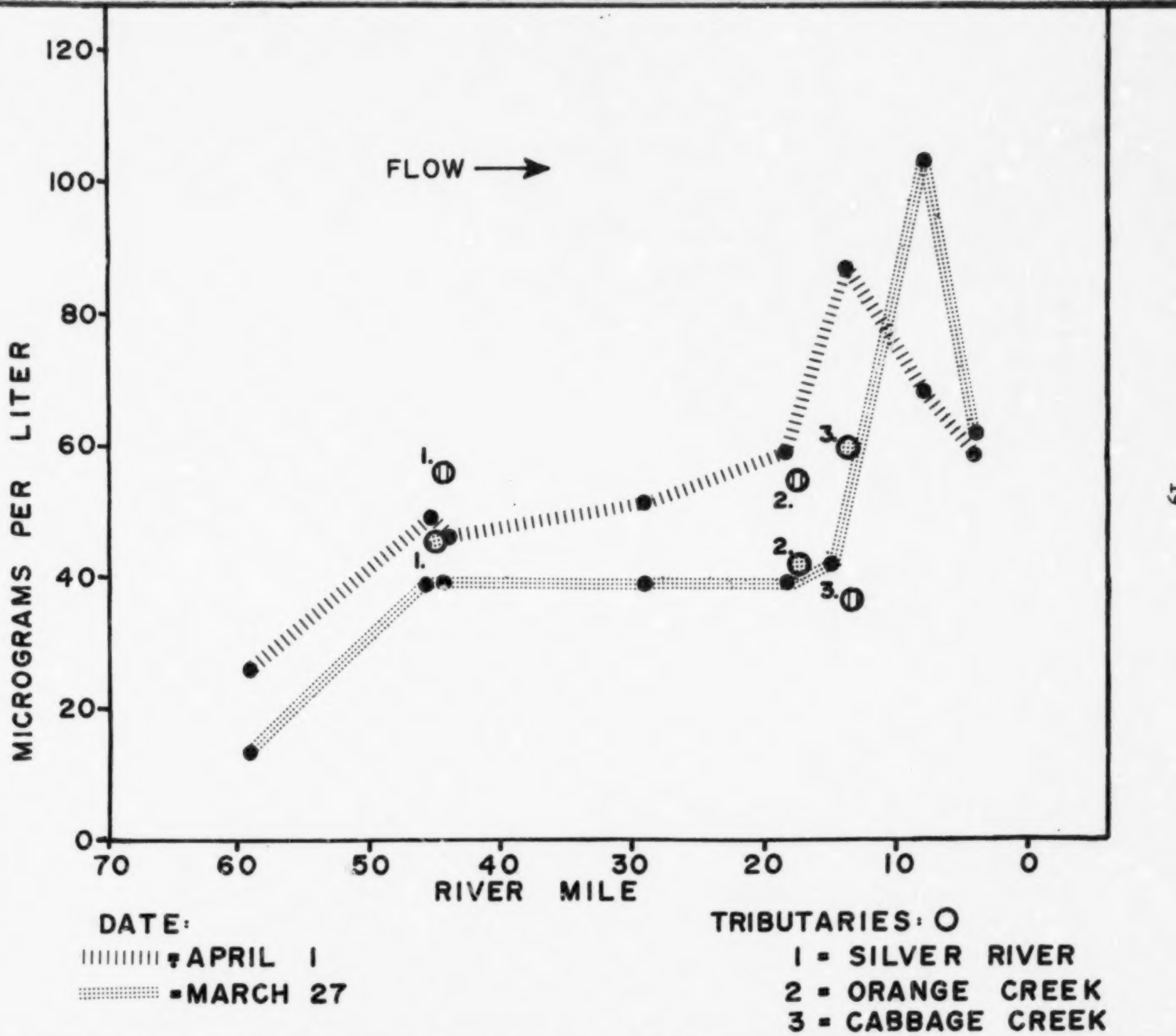


FIGURE 5. TOTAL PHOSPHORUS CONCENTRATIONS, OKLAWAHA RIVER, FLORIDA.

Within a short distance downstream from the confluence of Silver River the nitrogen concentrations in the Oklawaha decreased rapidly (Figure 6). The swift flowing and turbulent waters are not conducive to plankton growth and survival. After death of the algae, the organic nitrogen was decomposed and through the process of denitrification the nitrogen probably was released from the waters to the atmosphere. Orange Creek, a tributary that drains fertile lakes and lands lying north of Ocala discharged waters containing 2,000 micrograms per liter of nitrogen to the Oklawaha, but the much larger volume of the receiving stream diluted this concentration to an undetectable change in the Oklawaha.

Canal construction activities did not produce significant nitrogen increases in the river. This would be expected because the disturbed well-decayed organic swamp materials would contain relatively small proportions of nitrogenous material.

Phytoplankton, microscopic suspended algae, populations were very high in the quiescent waters from Moss Bluff downstream to the confluence of Silver River (Figure 7). The large volume of plankton free water discharged to the Oklawaha River via Silver River diluted the plankton rich waters, the turbulence destroyed that remaining, and regrowth of suspended algae did not occur in the river.

The attached algal growths in the Oklawaha River were most abundant in the nutrient enriched waters (Figure 8). The smallest quantities were observed in the mid-reach of the stream where the swift waters could scour

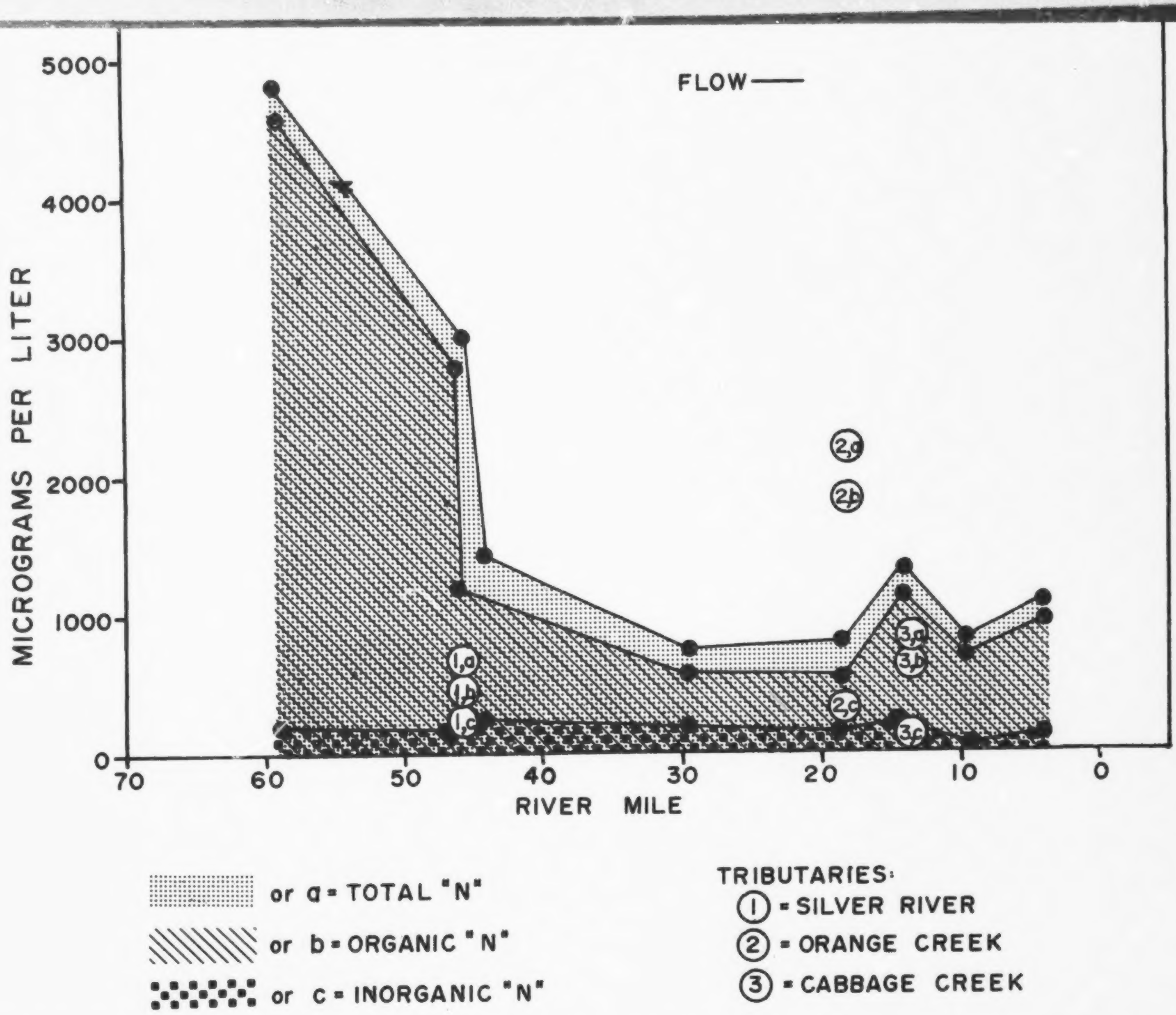
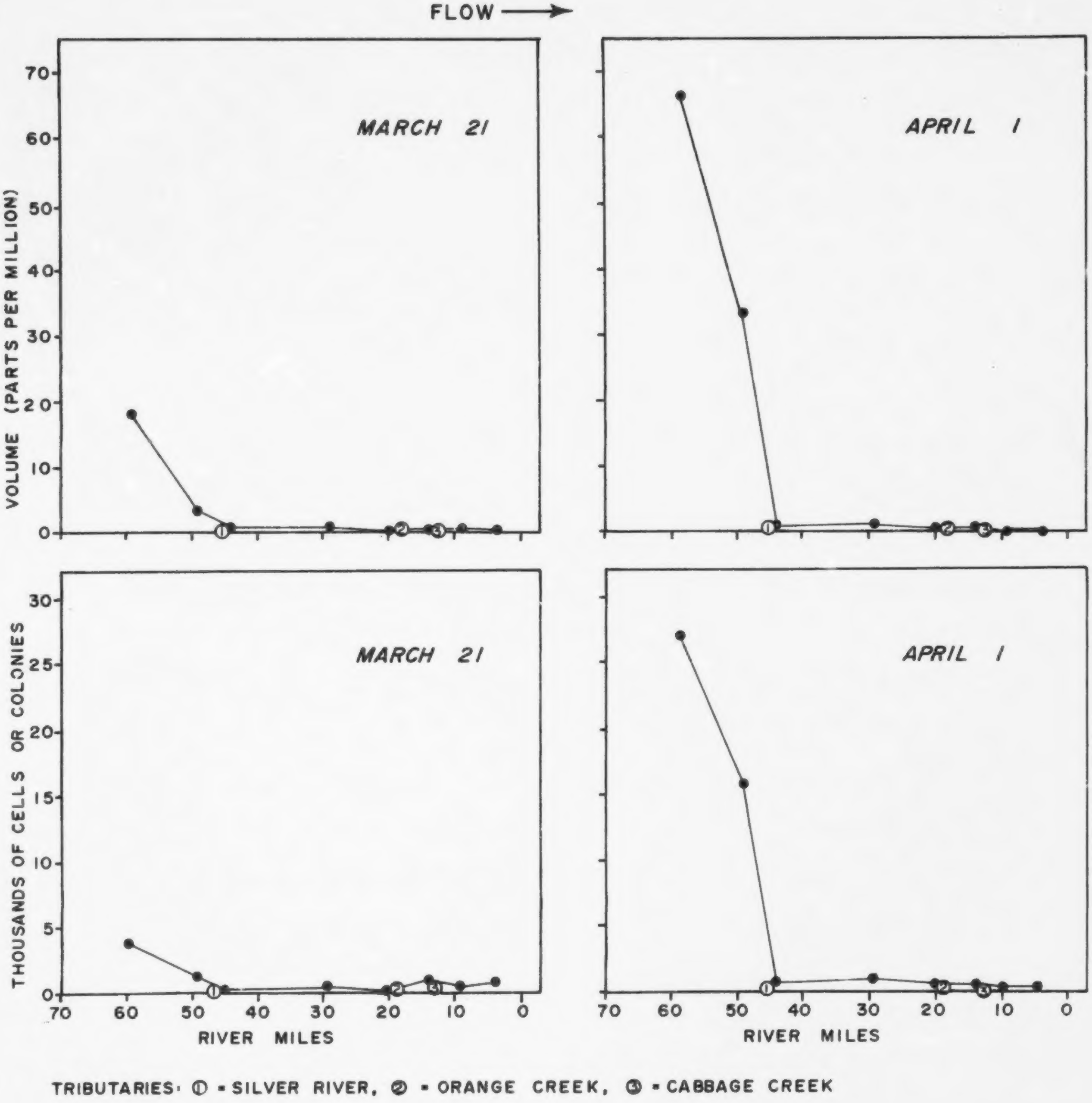


FIGURE 6. CONCENTRATIONS OF NITROGENOUS MATERIALS IN THE OKLAWAHA RIVER, FLORIDA.



IGURE 7. PHYTOPLANKTON IN THE OKLAWAHA RIVER, FLORIDA.

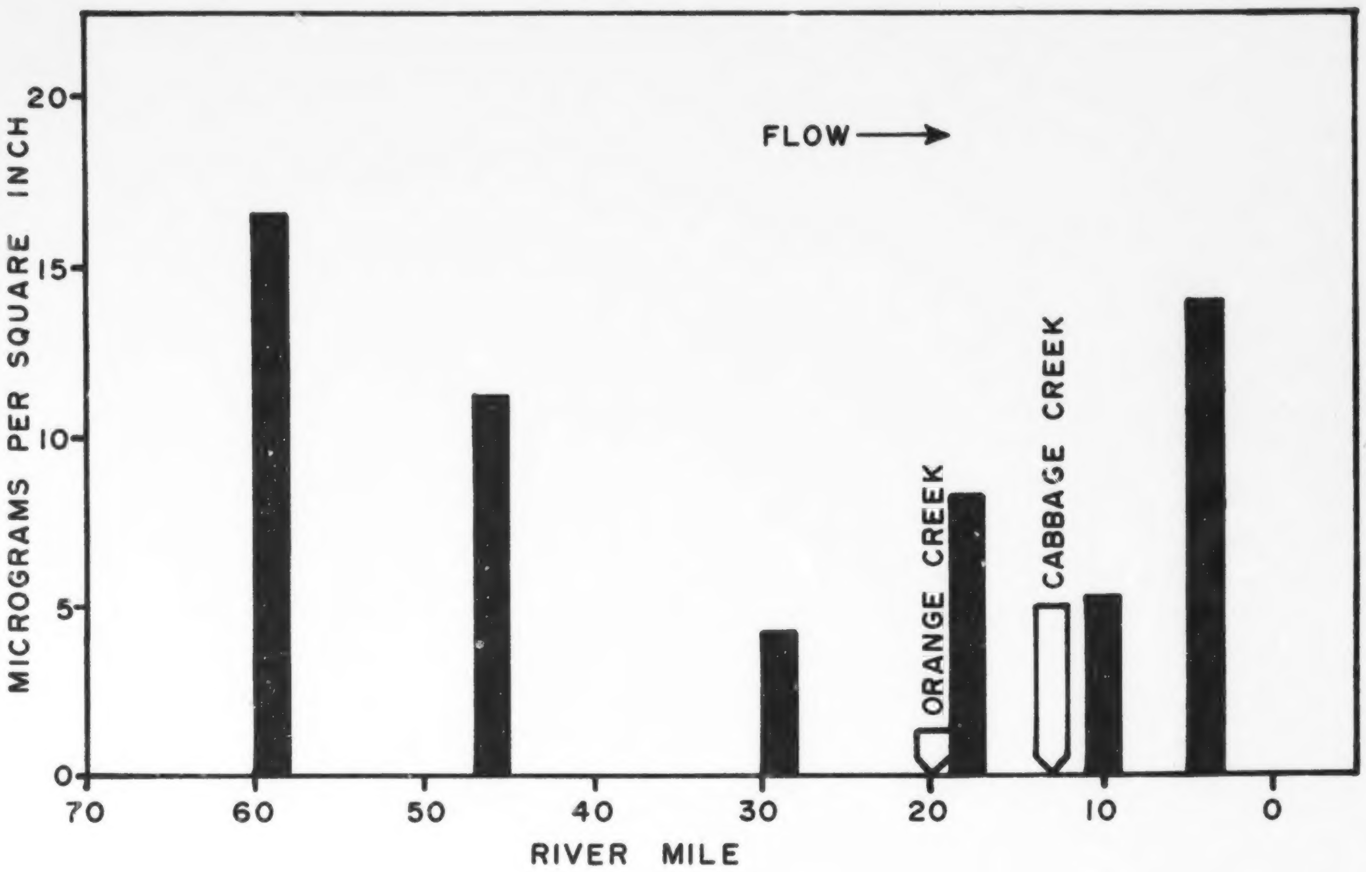


FIGURE 8. ATTACHED ALGAE (AS CHLOROPHYLL) IN THE OKLAWAHA RIVER, FLORIDA.

the growing algae as the community grew up from the substrate surface, thereby controlling the net accumulation; and this reach also was subjected to extensive shading by stream bank vegetation overhanging the narrow channel.

Comparison of the chlorophyll content and the carbon content of the attached algal growths indicated the growths were very viable (i.e. rate of growth and photosynthesis). The carbon-chlorophyll ratios were all 1.0 * or less (Figure 9). Values as low as this are indicative of very high production rates by attached algal growths. Only very small proportions of the carbon present were attributable to dead or non-viable algae, and extraneous organic materials.

Bottom Animals

Many kinds of bottom animals were found at the stations sampled in the Oklawaha River. The excellent water quality permitted animals of all types to live here (Figure 10). The upstream most station (Moss Bluff) supported a lesser variety of animals with a reduction in the proportion of sensitive forms; this change is related to the organic enrichment of the stream by the abundant algae. A similar change towards an organic enriched environment was observed in the vicinity of Jacksons Landing (River Mile 9.7), but this change is related to an increase in organic materials resulting from dredging and land clearing activities. The bottom animal communities indicated that the waters were excellent for the propagation of aquatic animal life.

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* Carbon-chlorophyll ratio is expressed as the milligrams of carbon divided by micrograms of chlorophyll X 10^3.

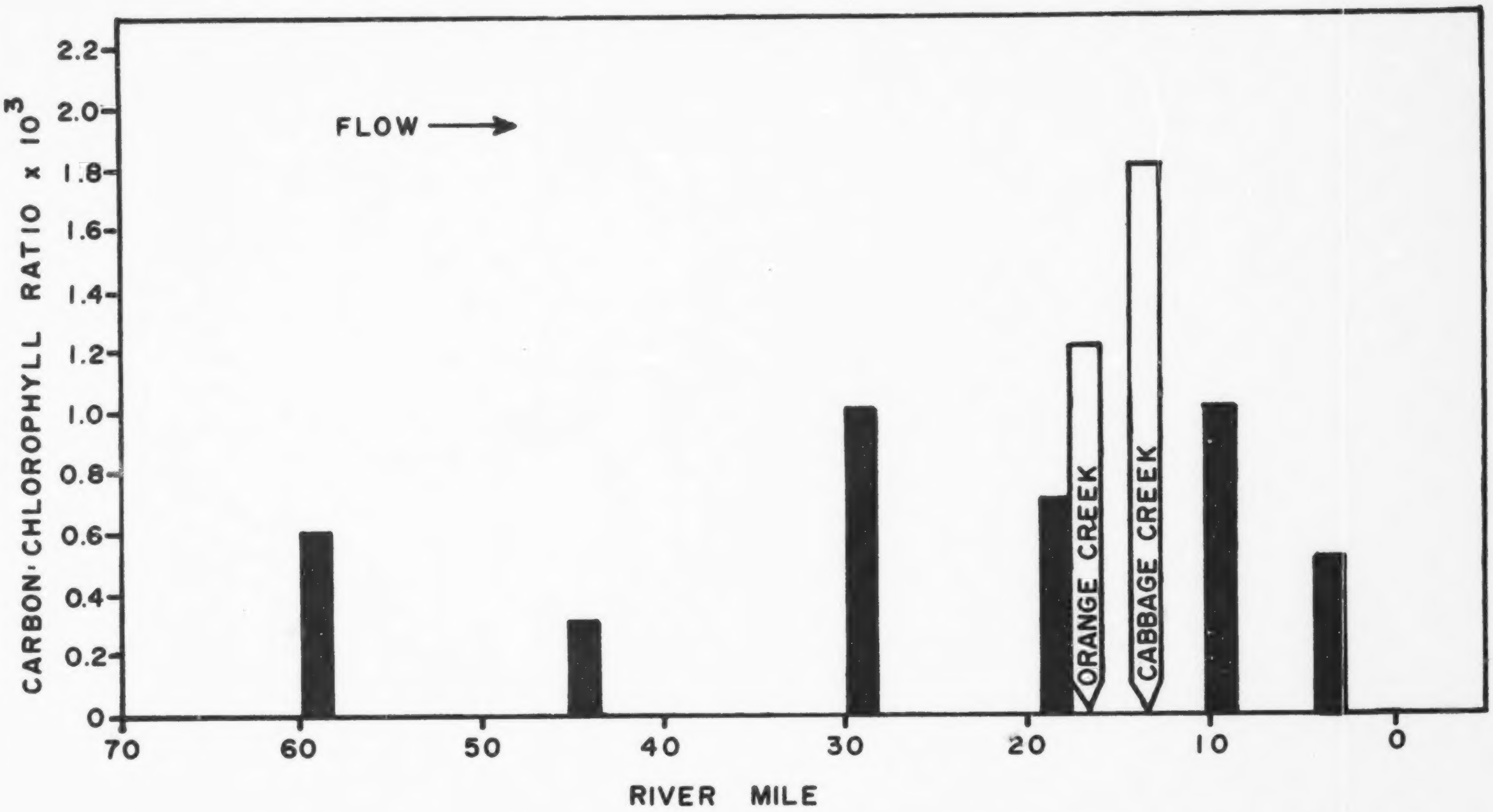
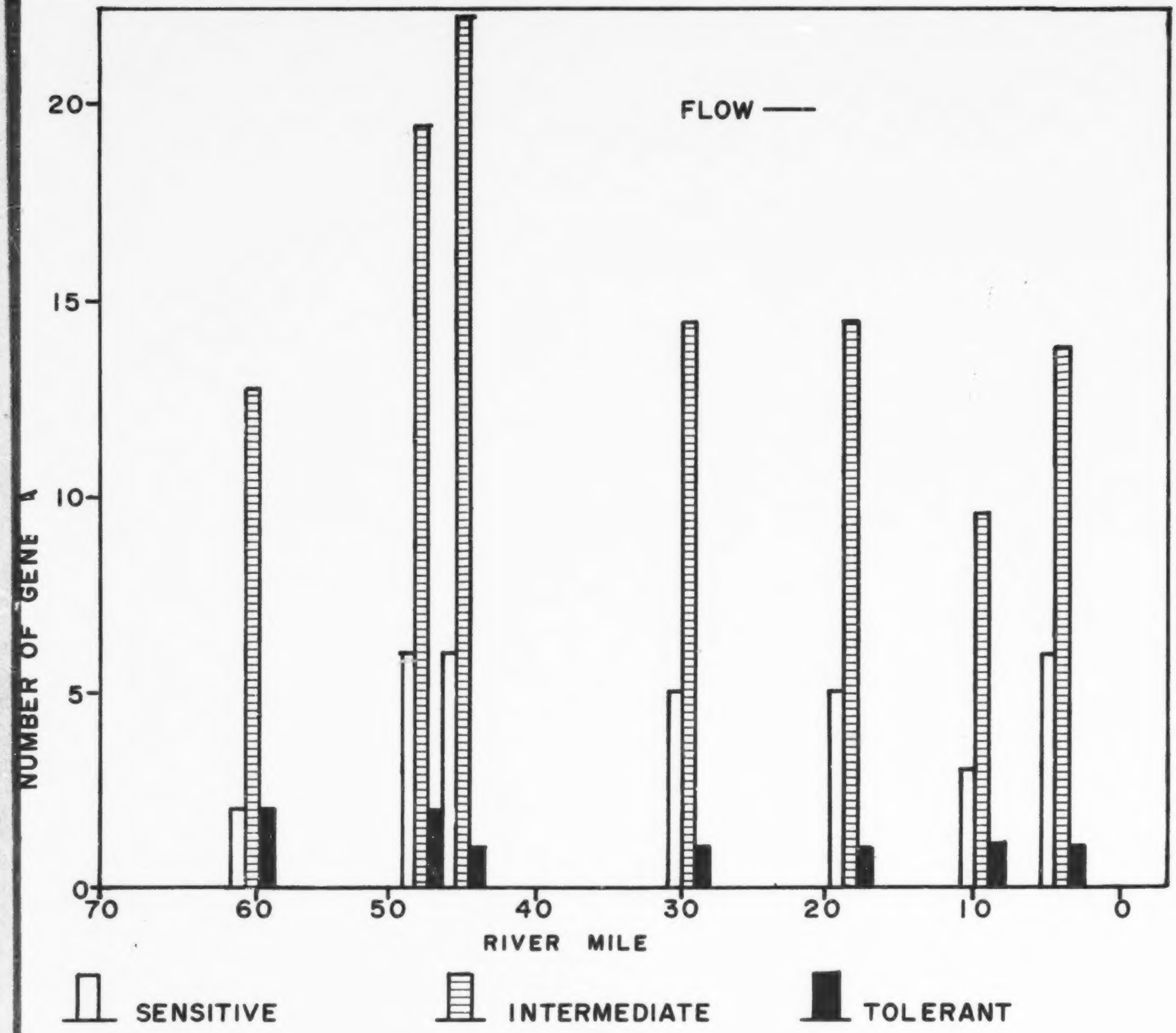


FIGURE 9. CARBON–CHLOROPHYLL RATIOS OF ATTACHED ALGAL GROWTHS IN THE OKLAWAHA RIVER, FLORIDA.



GURE 10. THE KINDS OF BOTTOM ANIMALS IN THE OKLWAHA RIVER, FLORIDA.

TABLE 1 - NITROGEN AND PHOSPHORUS CONCENTRATIONS IN THE WITHLACOOCHEE RIVER, FLORIDA
(All values in micrograms per liter and as the element)

Station	River Mile	Date	Total Phosphorus	Ammonia Nitrogen	Nitrate Nitrogen	Organic Nitrogen
MAINSTREAM						
Stokes Ferry	33.0	4/7	26	60	16	450
		4/14	29	20	20	650
Dunnellon	23.0	4/7	46	< 10	50	250
		4/14	36	10	47	410
Head of Lake Inglis	20.5	4/7	101	30	45	460
		4/14	189	30	45	630
Lake Inglis at Dam	10.5					
Surface Waters		4/7	26	< 10	2	420
		4/14	26	40	11	810
Bottom Waters		4/7	29	< 10	2	410
		4/14	26	50	9	680
Tailrace of Inglis Dam	10.3	4/7	33	20	5	350
		4/14	29	10	7	630
Yankeetown	7.0	4/7	29	20	339	460
		4/14	33	50	9	690
TRIBUTARY						
Blue Run	23.5*	4/7	42	< 10	90	100
		4/14	36	< 10	95	130

*River mile of mainstream at confluence.

TABLE 2 - PHYTOPLANKTON IN THE WITHLACOOCHEE RIVER, FLORIDA

			NUMBER OF ALGAE					VOLUME (Parts Per Million)				
Station	River Mile	Date	Diatoms	Green Algae	Flagellated Algae	Blue-green Algae	Total Number	Diatoms	Green Algae	Flagellated Algae	Blue-green Algae	Total Volume
MAINSTREAM												
Stokes Ferry	33.0	4/4	600	-	200	-	800	0.11	-	0.08	-	0.19
		4/14	-	100	-	-	100	-	0.09	-	-	0.09
Dunnellon	23.0	4/4	400	-	-	-	400	0.17	-	-	-	0.17
		4/14	300	-	-	-	300	1.50	-	-	-	1.50
Head of Lake Inglis	20.5	4/4	Not sampled.									
		4/14	900	400	-	-	1,300	1.31	1.88	-	-	3.19
Lake Inglis at Dam	10.5											
Surface Waters		4/4	800	-	-	-	800	0.47	-	-	-	0.47
		4/14	-	300	200	-	500	-	0.45	0.13	-	0.58
Bottom Waters		4/4	100	100	300	-	500	0.07	0.01	0.05	-	0.13
		4/14	-	100	200	-	300	-	0.03	0.05	-	0.08
Tailrace of Inglis Dam	10.3	4/4	-	-	100	-	100	-	-	0.03	-	0.03
		4/14	200	200	100	-	500	0.02	0.14	0.03	-	0.19
Yankeetown	7.0	4/4	-	-	-	-	< 50	-	-	-	-	< 0.01
		4/14	-	-		-	100	-	-	0.02	-	0.02
TRIBUTARY												
Blue Run	23.5*	4/4	100	100	-	-	200	0.25	0.05	-	-	0.30
		4/14	200	-	-	100	300	0.05	-	-	0.04	0.09

*River mile of mainstream at confluence.

TABLE 3 - BOTTOM ANIMALS, WITHLACOOCHEE RIVER, FLORIDA
(Number Per Square Foot)

Station (River Mile) ——————>	1 Mile Above Dunnellon (25.5)	Head of Lake Inglis (20.5)	Below Inglis Dam (10.0)	Tributary Blue Run (5.0)
	SENSITIVE ANIMALS			
Mayflies (Ephemeroptera)				
Hexagenia	27	1	-	-
Stenonema	-	Q	3	-
Ameletus	Q	Q	27	Q
Caenis sp.	-	Q	-	-
Tricorythodes	-	Q	-	Q
Caddisflies (Trichoptera)				
Polycentropus	10	1	Q	Q
Cheumatopsyche	-	-	10	-
Potamyia	Q	-	-	-
Hydropsyche	-	-	2	-
Oxyethira	-	-	-	Q
Hellgrammites (Megaloptera)				
Corydalus	-	-	Q	-
Shrimp (Decapoda)				
Palaemonetes	Q	Q	-	Q
	INTERMEDIATE ANIMALS			
Soldier Flies (Stratiomyiidae)				
Odontomyia	-	Q	-	-
Clams (Pelecypoda)				
Corbicula	5	1955	441	-
Elliptio	6		4	15
Snails (Gastropoda)				
Neritina	-	Q	-	-
Physa	Q	Q	1	1
Pomacea	Q	-	Q	Q
Pleurocera	Q	3	Q	1
Gyraulus	-	Q	1	-
Planorbula	-	-	Q	-
Craneflies (Tipulidae)				
Tipula	-	Q	-	-
Beetles (Coleoptera)				
Stenelmis	-	-	2	-
Midges (Tendipedidae)				
Tendipes	1	Q	8	4
Pseudochironomus	Q	Q	-	8
Cricotopus	-	Q	-	2
Polypedilum	Q	Q	-	3
Pelopia	Q	Q	-	-
Pentaneura	Q	-	-	Q
Anatopynia	Q	-	-	-
Spaniotoma	Q	Q	Q	Q
Biting Midges (Ceratopogonidae)				
Bezzia	Q	-	-	-
Scuds (Amphipoda)				
Hyalella	2	Q	193	12
Aquatic Sow Bugs (Isopoda)				
Asellus	-	-	Q	-
Damselflies (Odonata)				
Argia	-	-	-	Q
Ischnura	-	Q	-	Q
Nehallenia	Q	Q	-	Q
Dragonflies (Odonata)				
Gomphus	1	-	-	-
Tetragoneuria	Q	-	-	Q
	TOLERANT ANIMALS			
Mosquitoes (Culicidae)				
Anopheles	-	-	-	Q
Leeches (Hirudinea)	-	-	Q	Q
Sludgeworms (Tubificidae)	10	60	1	Q

Q = Forms present, but not collected quantitatively.

TABLE 4 - ANALYSES OF PERIPHYTON
WITHLACOOCHEE AND OKLAWAHA RIVERS, FLORIDA

	River Mile	Chlorophyll µg/sq. inch	Carbon mg/sq. inch
OKLAWAHA RIVER BASIN			
Mainstream, Oklawaha River:			
Moss Bluff	59.3	16.5	10.1
Highway 40	44.9	11.3	3.8
Eureka	29.4	4.2	4.1
Orange Ferry	18.4	8.2	5.5
Jacksons Landing	9.7	5.1	5.3
Highway 19	3.7	13.9	6.4
Tributaries of Oklawaha River:			
Orange Creek	18.3*	1.3	1.6
Cabbage Creek	13.9*	4.9	8.7
WITHLACOOCHEE RIVER BASIN			
Mainstream, Withlacoochee River:			
Stokes Ferry	33.0	< 0.4	2.4
Dunnellon	23.0	20.7	5.5
Downstream from Dunnellon	20.5	< 0.4	4.0
Inglis Lake at Dam	10.5	< 0.3	2.6
Downstream from Inglis Dam	10.3	0.6	2.0
Yankeetown	7.0	< 0.4	2.3
Tributary of Withlacoochee:			
Blue Run	23.5*	12.4	4.8

***River mile of mainstream at confluence.**

TABLE 5 - NITROGEN AND PHOSPHORUS CONCENTRATIONS IN THE OKLAWAHA RIVER, FLORIDA
(All values in micrograms per liter and as the element)

Station	River Mile	Date	Total Phosphorus	Ammonia Nitrogen	Nitrate Nitrogen	Organic Nitrogen
MAINSTREAM						
Moss Bluff	59.3	3/27	13	300	14	6,700
		4/4	26	60	7	2,520
Sharps Ferry	47.5	3/27	39	200	20	2,920
		4/4	49	150	16	2,710
Highway 40	44.9	3/27	39	330	124	1,780
		4/4	46	< 10	133	490
Eureka	29.4	3/27	39	180	95	200
		4/4	52	60	102	930
Orange Ferry	18.4	3/27	39	30	88	560
		4/4	59	190	86	550
Cedar Landing	14.3	3/27	42	30	57	1,850
		4/4	88	280	68	430
Jacksons Landing	9.7	3/27	104	20	52	750
		4/4	68	10	57	740
Highway 19	3.7	3/27	62	40	47	1,000
		4/4	59	< 10	160	940
TRIBUTARIES						
Silver River	44.9*	3/27	46	240	120	30
		4/4	55	< 10	122	790
Orange Creek	18.4*	3/27	39	80	484	1,780
		4/4	55	50	23	1,990
Cabbage Creek	13.9*	3/27	59	70	2	1,130
		4/4	36	130	2	270

*River mile of mainstream at confluence.

TABLE 6 - PHYTOPLANKTON IN THE OKLAWAHA RIVER, FLORIDA

			NUMBER OF ALGAE					VOLUME (Parts Per Million)				
Station	River Mile	Date	Diatoms	Green Algae	Flagellated Algae	Blue-green Algae	Total Number	Diatoms	Green Algae	Flagellated Algae	Blue-green Algae	Total Volume
MAINSTREAM												
Moss Bluff	59.3	3/21	-	1,000	-	2,800	3,800	-	0.35	-	17.34	17.69
		4/1	700	2,800	400	23,200	27,100	0.24	0.81	0.04	64.31	65.40
Sharps Ferry	47.5	3/21	100	900	-	-	1,000	0.01	0.24	-	-	0.30
		4/1	1,000	3,500	-	11,300	15,800	0.51	1.41	-	31.32	33.24
Highway 40	44.9	3/21	100	-	-	-	100	0.20	-	-	-	0.20
		4/1	-	100	300	300	700	-	0.01	0.10	0.83	0.94
Eureka	29.4	3/21	200	-	-	-	200	0.03	-	-	-	0.03
		4/1	400	300	-	300	1,000	0.18	0.14	-	0.83	1.15
Orange Ferry	18.4	3/21	100	-	-	-	100	< 0.01	-	-	-	< 0.01
		4/1	200	150	100	250	700	0.24	0.04	0.01	0.69	0.98
Cedar Landing	14.3	3/21	500	-	100	-	600	0.04	-	0.05	-	0.09
		4/1	150	450	-	-	600	0.22	0.23	-	-	0.45
Jacksons Landing	9.7	3/21	250	-	50	-	300	0.05	-	0.21	-	0.27
		4/1	150	150	-	-	300	0.04	0.01	-	-	0.05
Highway 19	3.7	3/21	400	400	-	-	800	0.11	0.02	-	-	0.13
		4/1	50	350	-	-	400	< 0.01	0.09	-	-	0.10
TRIBUTARIES												
Silver River	44.9*	3/21	< 50	-	-	-	< 50	< 0.01	-	-	-	< 0.01
		4/1	-	100	100	-	200	-	0.01	0.01	-	0.02
Orange Creek	18.4*	3/21	-	-	-	-	< 25	-	-	-	-	< 0.01
		4/1	50	100	-	-	150	< 0.01	0.02	-	-	0.02
Cabbage Creek	13.9*	3/21	-	-	-	-	< 50	-	-	-	-	< 0.01
		4/1	100	50	-	-	150	0.04	0.04	-	-	0.08

*River mile of mainstream at confluence.

TABLE 7 - BOTTOM ANIMALS, OKLAWAHA RIVER, FLORIDA
(Number Per Square Foot)

Station ———> (River Mile) ———>	Moss Bluff (59.3)	Upstream of Silver River (47.0)	Highway 40 (44.9)	Eureka (29.4)	Orange Springs Ferry (18.4)	Jackson's Landing (9.7)	Highway 19 (3.7)	Tributary, Orange Creek
				SENSITIVE ANIMALS				
Stoneflies (Plecoptera)	-	-	-	-	-	-	-	0
Neoperla	-	-	-	-	-	-	-	0
Mayflies (Ephemeroptera)								
Stenonema	-	0	-	-	-	-	0	0
Ameletus	-	0	0	1	0	-	0	-
Tricorythodes	-	-	6	0	0	0	1	-
Ephemerella	-	-	-	-	-	0	-	-
Siphlonurus	0	-	-	-	-	-	-	-
Caenis	-	-	-	-	0	-	-	-
Hexagenia							0	
Caddisflies (Trichoptera)								
Potamyia	-	-	-	-	-	-	-	0
Cheumatopsyche	-	0	83	-	0	-	0	0
Polycentropus	-	0	5	-	-	-	-	-
Oxyethira	-	-	-	-	-	-	-	0
Hellgrammites (Megaloptera)								
Sialis	-	-	-	1	-	-	-	-
Corydalus	-	0	2	0	-	-	-	0
Shrimp (Decapoda)								
Palaemonetes	0	0	0	0	0	0	1	0
Crayfish (Decapoda)				INTERMEDIATE ANIMALS				
Cambarinae	-	-	-	-	-	0	-	0
Aquatic Caterpillars (Pyralididae)								
Elophila	-	-	0	-	0	-	-	-
Clams (Pelecypoda)								
Sphaerium	0	1	6	-	-	-	-	-
Elliptio	0	18	-	-	-	-	-	-
Medionidus		6	6					0
Snails (Gastropoda)								
Physa	0	0	1	-	0	0	0	-
Gyraulus	1	0	6	-	0	-	-	-
Pomacea	-	-	0	0	-	-	-	-
Campeloma	0	-	1	0	0	-	85	0
Lymnaea	-	-	-	-	-	0	-	-
Planorbula	-	-	-	0	-	-	-	-
Pleurocera	-	-	-	0	-	-	-	-
Crane Flies (Tipulidae)								
Hexatoma	-	-	0	-	-	-	-	-
Beetles (Coleoptera)								
Haltrevia	-	-	-	-	-	-	-	0
Ancyronyx	-	0	-	-	-	-	-	-
Ordobrevia	-	0	1	-	0	-	-	-
Dubiraphia	-	-	0	-	-	-	-	-
Dineutus	1	-	-	-	0	-	0	-
Cylloepus	-	-	-	0	-	-	-	-
Heterelmis	-	-	-	-	-	-	-	0
Stenelmis	-	-	-	-	-	-	-	0
Midges (Tendipedidae)								
Spaniotoma	0	-	76	1	0	-	11	0
Polypedilum	55	1	[illegible]	-	0	0	9	0
Chironomus	-	-	-	-	-	-	-	-
Pelopia	-	2	-	-	-	-	-	-
Pentaneura	0	0	16	0	0	0	1	0
Pseudochironomus	0	-	12	0	0	-	11	0
Tendipes	0	-	-	-	-	-	1	-
Anatopynia	-	-	2	-	-	-	-	-
Coelotanypus	-	-	-	2	-	4	-	-
Cryptochironomus	-	-	-	-	-	-	-	0
Biting Midges (Ceratopogonidae)								
Probezzia	1	0	8	-	-	-	-	-
Black Flies (Simuliidae)								
Simulium	-	-	-	-	0	-	-	-
Scuds (Amphipoda)								
Hyalella	1	1	-	-	0	-	-	-
Gammarus			17	10	0	0	8	0
Aquatic Sow Bugs (Isopoda)								
Sphaeroma	-	-	0	-	-	-	0	-
Damselflies (Odonata)								
Argia	-	0	-	-	-	-	-	-
Agrion	-	0	-	-	-	-	0	-
Nehalennia	-	-	0	-	0	0	0	-
Ischnura	-	-	-	0	-	0	0	0
Telagrion	-	-	-	-	-	-	-	0
Dragonflies (Odonata)								
Dromogomphus	-	-	-	-	-	-	-	0
Macromia	-	0	-	0	-	-	-	0
Tetragoneuria	-	0	1	0	-	-	-	-
Gomphus	-	-	1	-	-	-	0	-
Epicordulia	-	-	-	-	-	-	-	0
Danceflies (Empididae)	-	-	1	-	-	-	-	-
Phantom Midges (Culicidae)								
Chaoborus	-	1	-	-	-	-	-	-
Bloodworms (Chironomidae)				TOLERANT ANIMALS				
Chironomus	0	-	-	-	-	-	-	-
Leeches (Hirudinea)	-	2	-	-	-	-	-	-
Sludgeworms (Tubificidae)	8	56	16	22	-	53	38	17

0-Forms present, but not collected quantitatively.

DESCRIPTION OF SAMPLING STATIONS

WITHLACOOCHEE RIVER

River Mile		Type of Sample*
7.0	Near Yankeetown and Inglis, U. S. Highways 19 and 28 Bridge	A,B,C.
10.3	Tailrace of Inglis Dam	A,B,C,D.
10.5	Inglis Lake at Dam	A,B,C.
20.5	Head of Lake Inglis, approximately three river miles downstream from Dunnellon	A,B,C,D.
23.5	Dunnellon, U. S. Highway 41 Bridge	A,B,C.
25.5	Two miles upstream from Dunnellon	D
33.0	Stokes Ferry. State Highway 488 Bridge	A,B,C.
Tributary	Blue Run, County Park three miles upstream from confluence with Withlacoochee River	A,B,C,D.

*A = Nutrients (nitrogen and phosphorus)
B = Phytoplankton
C = Attached algae
D = Bottom animals

OKLAWAHA RIVER

River Mile		Type of Sample*
3.7	State Highway 19 Bridge.	A,B,C,D.
9.7	"Jacksons Landing" on U. S. Forest Road Service Road Number 18	A,B,C,D.
14.3	Cedar Landing and Blue Springs, unmarked road south from State Highway 315	A,B.
18.4	Orange Ferry and Confluence of Orange Creek, two miles east of Orange Springs	A,B,C,D.
29.4	Eureka, State Highway 316 Bridge	A,B,C,D.
44.9	State Highway 40 Bridge.	A,B,C,D.
47.5	Sharpes Ferry, unnamed road crossing river two miles upstream from Silver River and State Highway 40	A,C,D.
59.3	Moss Bluff, State Highway 464 Bridge	A,B,C,D.
Tributary	Silver Springs, at Silver Springs Park	A,B.
Tributary	Orange Creek, State Highway 21 Bridge	A,B,C,D.
Tributary	Cabbage Creek, State Highway 310 Bridge.	A,B,C.

*A = Nutrients (Nitrogen and phosphorus)
B = Phytoplankton
C = Attached Algae
D = Bottom animals

ACKNOWLEDGMENTS

This study is a portion of a general water quality study undertaken by the Southeast Water Laboratory, Federal Water Pollution Control Administration for the Corps of Engineers. Engineering, chemical and microbiological aspects of the study were performed by personnel from the Southeast Water Laboratory, the Southeast Comprehensive Project, and the Hillsborough-Tampa Bay Technical Services Project of the Southeast Region, Federal Water Pollution Control Administration.

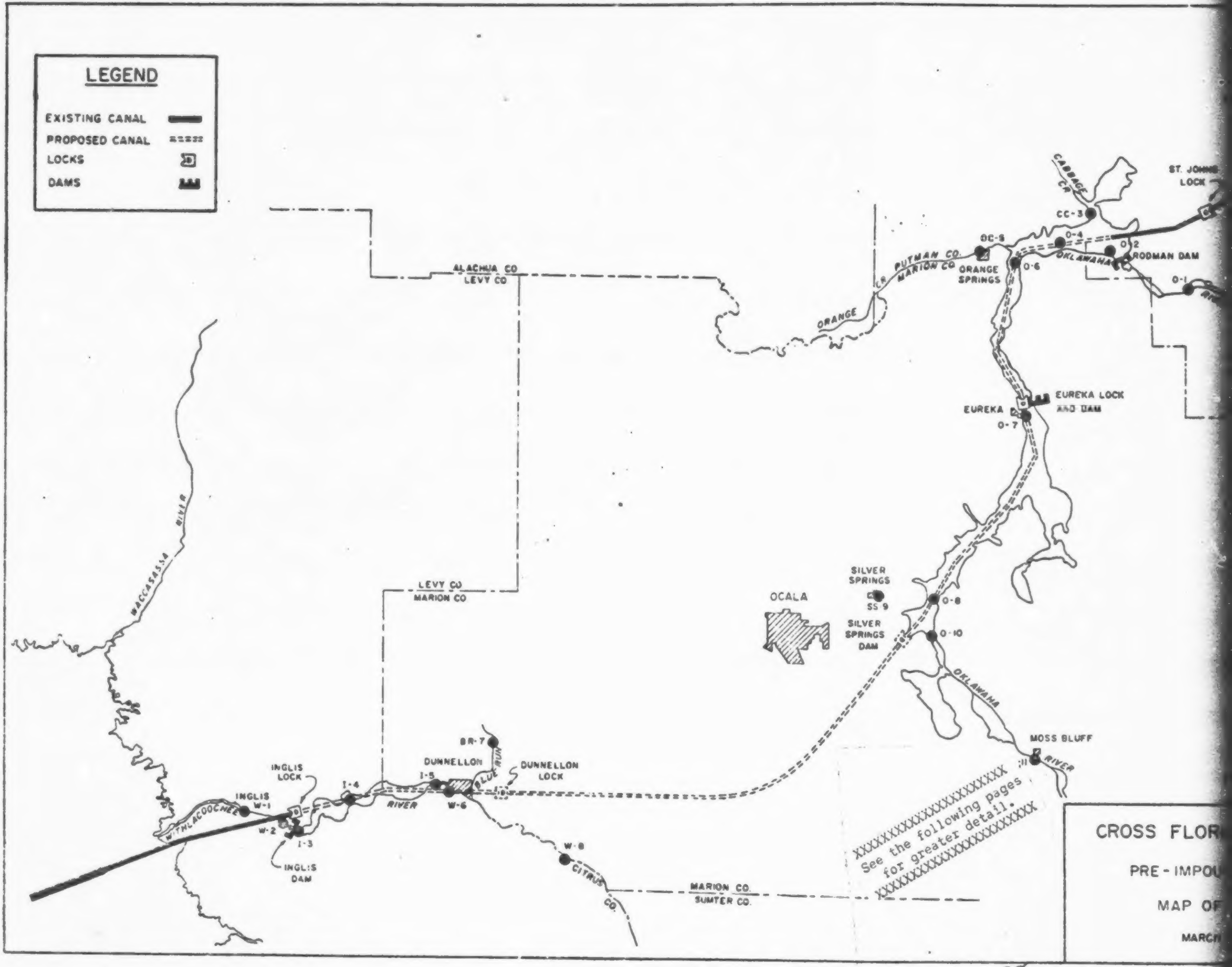
Personnel involved in the biological aspects of the study were as follows:

Field sampling--Lowell Keup, Aquatic Biologist, Technical Advisory and Investigations Branch, FWPCA, Cincinnati, Ohio; and David Smith, Physical Science Technician, Southeast Water Laboratory, FWPCA, Athens, Georgia.

Biological Laboratory Analysts--R. Keith Stewart, Loys Parrish, George Brown, and Cheryl O'Conner, Aquatic Biologists, Technical Advisory and Investigations Branch, FWPCA, Cincinnati, Ohio.

Chemical (nutrient) Analysts--Staff of Technical Services Program, Southeast Water Laboratory, FWPCA, Athens, Georgia.

Data Analyses and Report Preparation--Lowell Keup, Aquatic Biologist, Technical Advisory and Investigations Branch, FWPCA, Cincinnati, Ohio.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MARION CO
PUTMAN CO.
MARION CO
ORANGE CR
CABBAGE CR
CC-3
ST. JOHNS LOCK
OC-5
ORANGE SPRINGS
O-4
O-2
RODMAN DAM
O-6
OKLAWAHA
O-1
EUREKA
EUREKA LOCK AND DAM
O-7
WACCASASSA RIVER
SILVER SPRINGS
SS 9
OCALA
SILVER SPRINGS DAM
O-8
O-10
OKLAWAHA
MOSS BLUFF
11
RIVER
BR-7
BLUE RUN
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I-5
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W-2
I-3
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CITRUS CO.
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MAP OF
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See the following pages
for greater detail.
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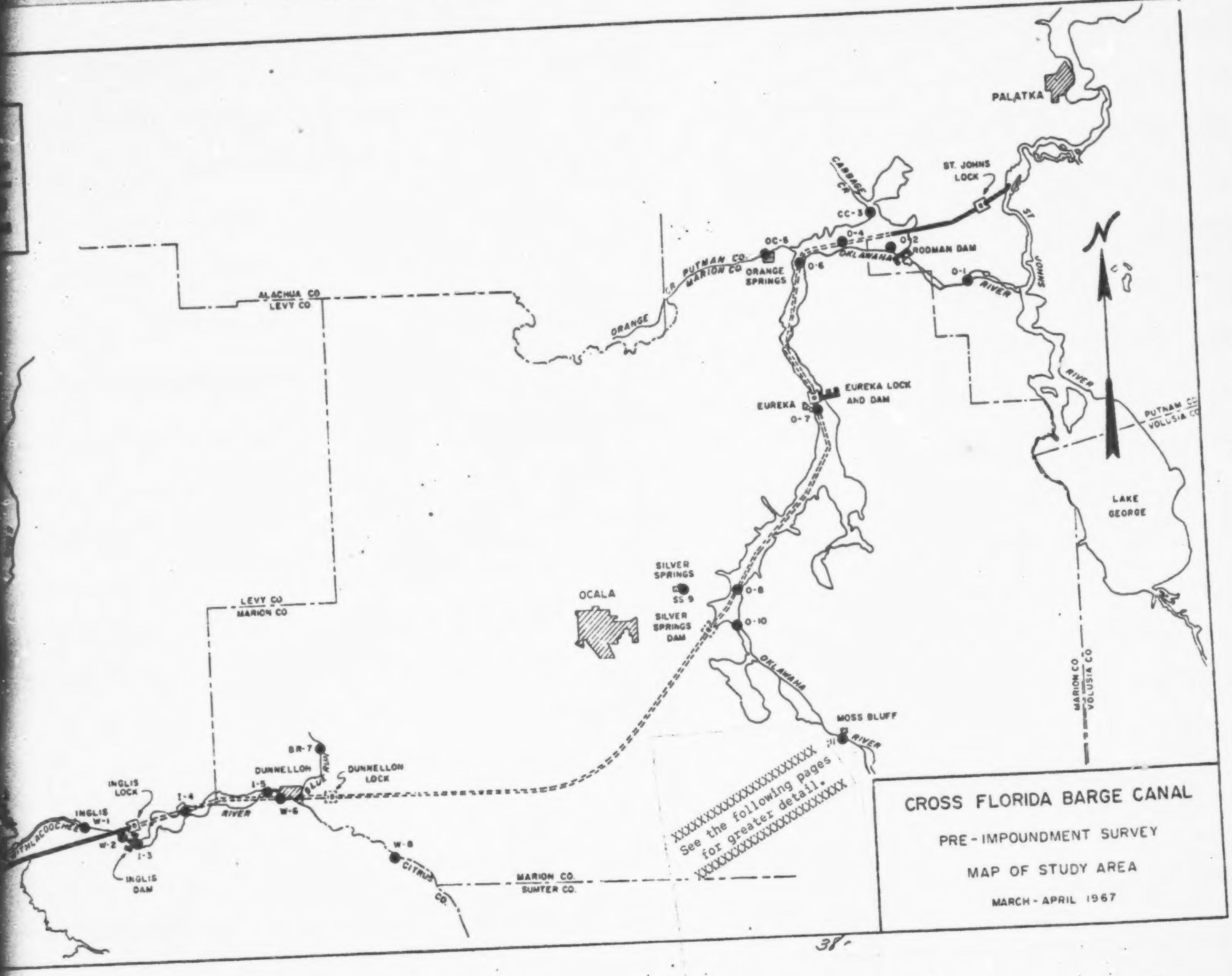
Figure 1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CROSS FLORIDA BARGE CANAL

PRE-IMPOUNDMENT SURVEY

MAP OF STUDY AREA

MARCH-APRIL 1967

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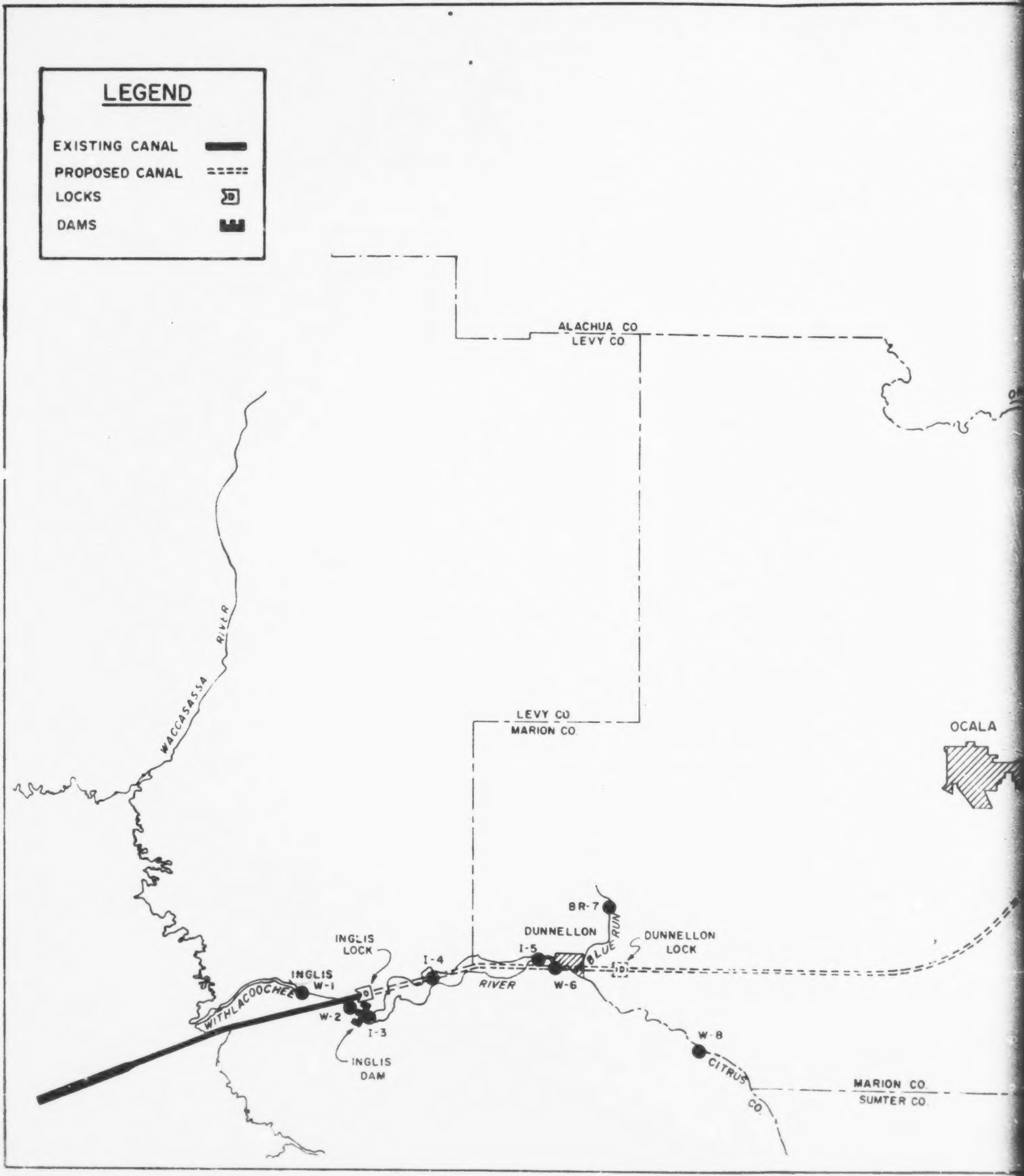
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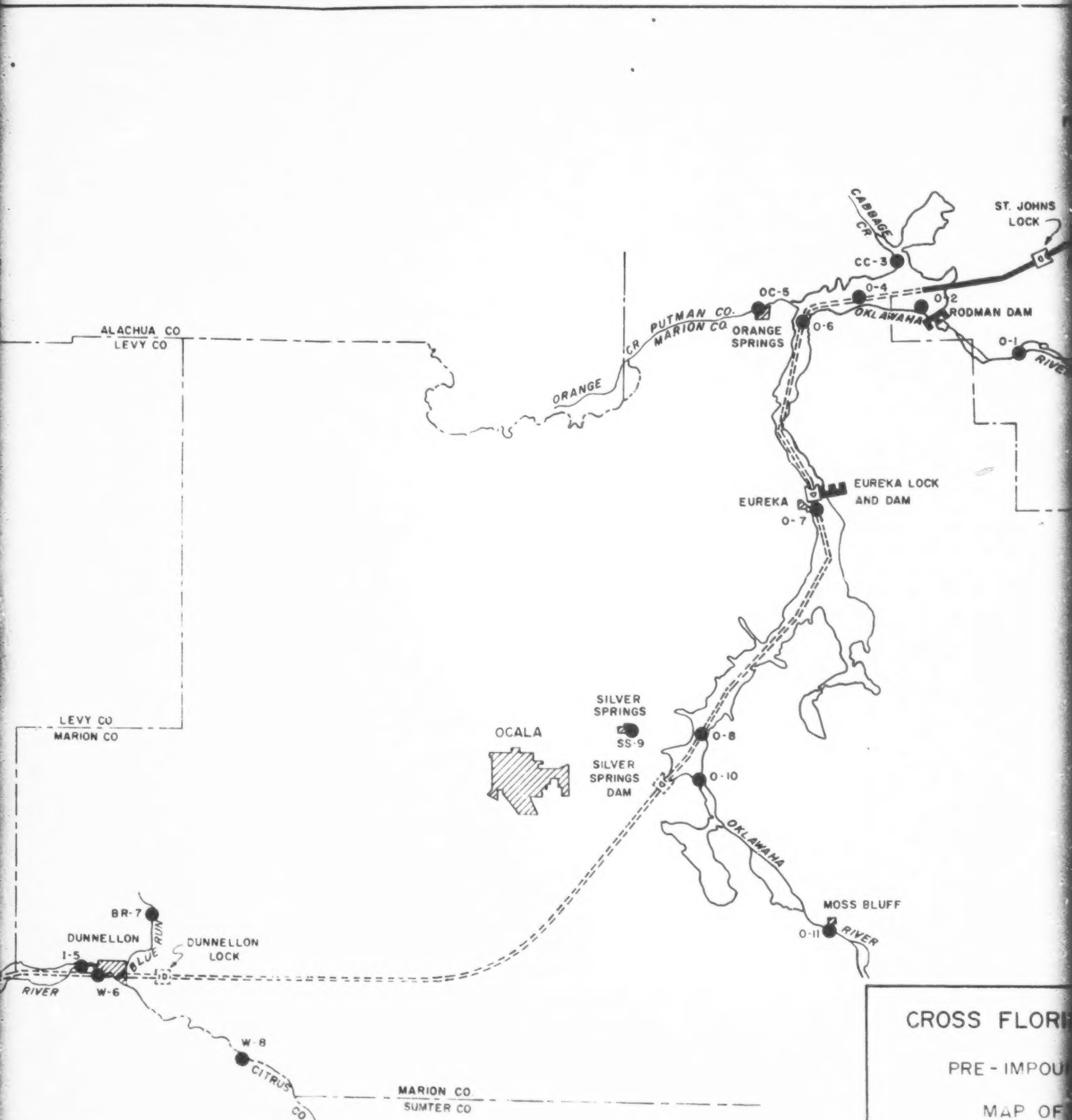
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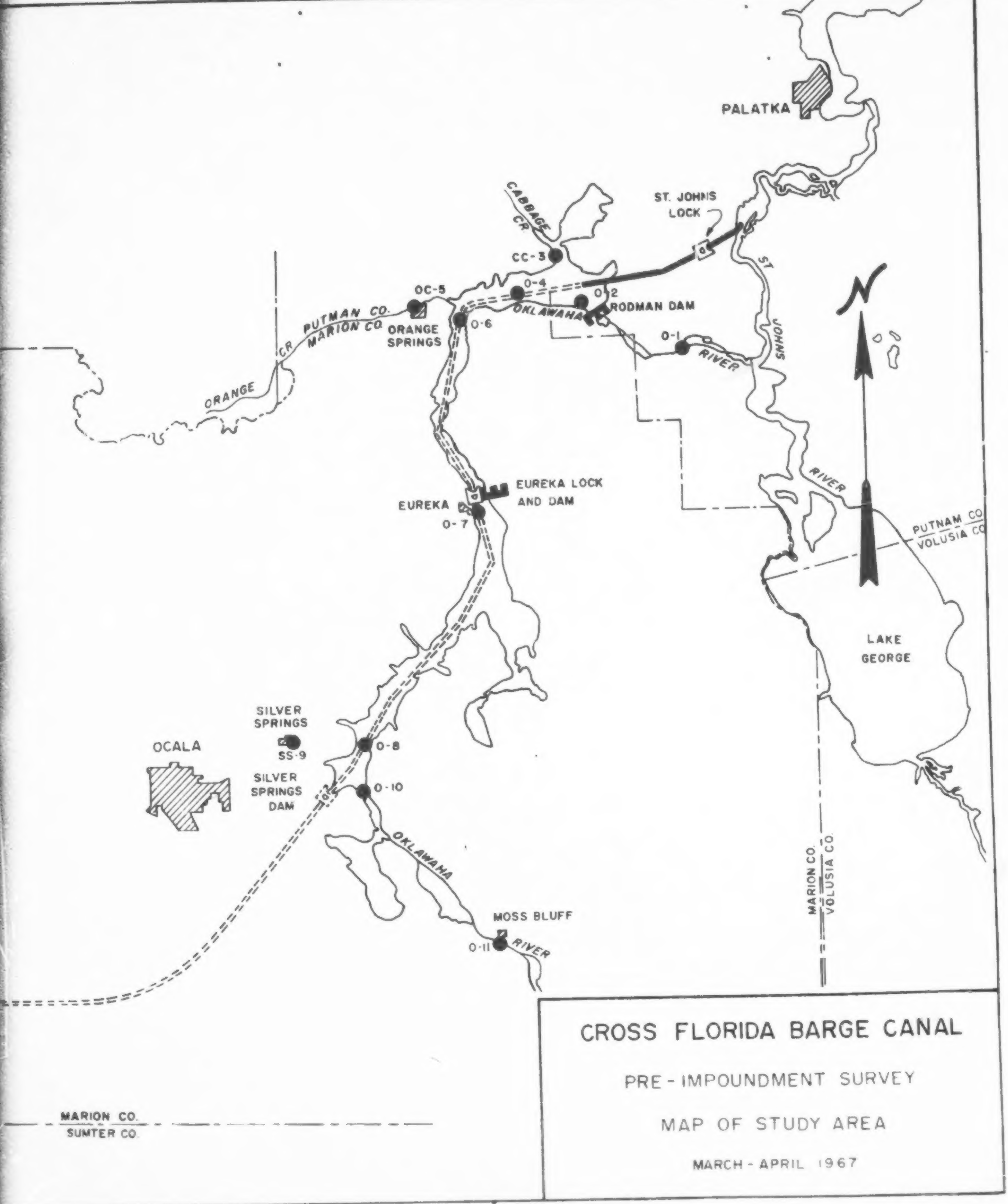
Figure I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